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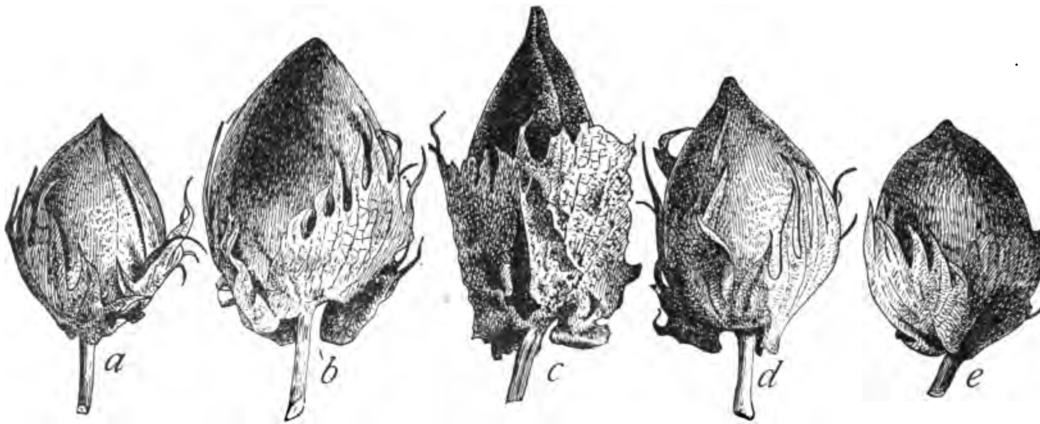
Conrad Kruse.



Types of mature unopened cotton bolls. Short staple upland varieties: *a* Excelsior; *b* Jones' Improved; *d* Parker; *e* King. Sea island cotton: *c* Seabrook. About two-thirds natural size
(From photos by Webber)

The Forage and Fiber Crops in America

BY

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PREFACE

In the pages which follow the characteristics of the forage and fiber crops are discussed, and the results of experiment and experience as to their climatic and soil adaptation, cultural methods, insect enemies, fungous diseases, harvesting, use, and marketing are summarized with special reference to American conditions. This volume with "The Cereals in America" is intended to cover the principal field crops as distinguished from garden and orchard crops raised in America. There are some omissions, such as coffee, hops, teasel, medicinal and aromatic herbs, which are more or less extensively raised as field crops. The most obvious omissions, however, are potatoes and tobacco. A recent book, "The Potato," by Samuel Fraser, makes a discussion of this important crop unnecessary.

With the exceptions noted, "The Cereals in America" and "The Forage and Fiber Crops in America" cover what in the historical and old Roman sense was known as agriculture (*Ager* open or field + *cultura* cultivation) in contradistinction to horticulture (*Hortus* enclosure or garden + *cultura* cultivation). Agriculture, however, has come to have a much wider meaning; viz., the science and art of producing living things. It is thus distinct from mining, manufacturing, trade and transportation. As the manufacturer, so is the farmer deeply concerned with trade and transportation, although these activities are neither manufacturing nor farming. Many an able farmer has failed of the financial success to which his ability as a farmer entitled him through a lack of skilful marketing of his products.

In order to prevent repetition, cross-reference is made not only to paragraphs in this volume, but also to those in "The Cereals in America." When reference is made to the latter volume, C. A. precedes the number of the paragraph to which reference is made.

In preparing the following pages, the author has had the advantage of the criticisms of his colleagues in the Department of Agronomy. Monographs on different farm crops, which have been prepared in the Department by postgraduate students, have been freely consulted and have proved helpful. The author is under special obligations to H. J. Webber for reading and criticising the manuscript on cotton, and to J. F. Duggar for a like service concerning the manuscript on cowpeas. J. G. Lipman not only read Chapter VII on Leguminous Forage Crops, but kindly prepared some paragraphs which have been included. The illustrations have been drawn largely by B. F. Williamson; while the author's secretary, C. C. Poindexter, has rendered efficient service in the preparation of materials for the text.

THOMAS F. HUNT.

CORNELL UNIVERSITY,
ITHACA, N. Y., June 1, 1907.

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I

PERENNIAL FORAGE GRASSES

I. CHARACTERS AND HABITS

1. Designation.—Under the above designation will occur a discussion of certain perennial species of the grass family (*Gramineae*) which are cultivated chiefly for hay, pasture, and lawns, although sometimes they also may be used for holding embankments, to prevent the shifting of sandy soils by the wind, or to prevent the erosion of soils through rains. Those annual species of the grass family used for forage are discussed elsewhere in this volume under the title of "Annual Forage Plants," while the cereals are treated in a separate volume.[1] The grasses which are cultivated exclusively for ornamental purpose will not be described. The use of the term grass to apply to plants other than true grasses, although used for the same purpose, will be avoided.

2. Relationships.—The grass family (*Gramineae*) is an important and rather isolated group of plants, being closely related only to the sedges from which it differs in important particulars. Of the 1,380 native and introduced species of grasses in the United States, the seeds of about 50 species have entered into commerce and may therefore be considered cultivated species. (C. A. 8) The most important perennial forage grasses in America belong to two of the 13 tribes of the grass family—namely, *Agrostideae* and *Festuceae*. To the former belong timothy, redtop, and meadow foxtail; while to the latter belong orchard grass, the fescues, smooth brome

[1] "The Cereals in America."

The Relationship of the Commonly Cultivated Perennial Forage Grasses with Some of the Less Common Species

Family	Tribe	Sub-tribe	Genus	Cultivated or Useful Forms
Gramineae	Phalarideae		Phalaris	Canary grass
				Reed grass
			Anthoxanthum	Sweet vernal grass
	Agrostideae	Stipeae	Stipa	Bunch grass
			Oryzopsis	Bunch grass
			Muhlenbergia	
		Phleoideae	Phleum	Timothy
			Alopecurus	Meadow foxtail
		Euagrosteae	Agrostis	Redtop
			Calamagrostis	Blue joint
	Aveneae		Holcus	Velvet grass
			Deschampsia	Occurs on high plains
			Avena	Common oat
			Arrhenatherum	Tall oat grass
			Danthonia	Valuable for grazing in mountains of North Carolina and Tennessee
	Festuceae	Eragrosteae	Koeleria	
		Eufestuceae	Briza	
			Dactylis	Orchard grass
			Cynosurus	Crested dog's tail
			Poa	Meadow grass, blue grass
			Glyceria	
			Festuca	Fescues
		Brachypodieae	Bromus	Smooth brome grass
			Brachypodium	
	Chlorideae		Capriola	Bermuda grass
			Bouteloua	Mesquite or grama grass
			Bulbilis	Buffalo grass

grass, and many species of the genus *Poa,* to which Kentucky blue grass belongs. These two tribes may be distinguished from each other by the fact that the spikelets in the cultivated species of the former are almost always one-flowered, while those of the latter are two—or more—flowered. In the former, the flowering glume is thin or hyaline and not longer than the outer glumes; while in the latter, it is thick and chartaceous and is no longer than the outer glumes. For classification of important species, see opposite page.

3. **Duration.**—While some annuals of the grass family are grown and harvested for forage—as millet, oats, barley, and maize—those grasses which we use for meadows and pastures are perennial, this character being an essential quality. All perennial grasses increase by new culms arising from the nodes, usually the lower ones, of the culm in more or less chain-like succession. The new culms may be sessile, when the process is similar to that of stooling in the cereal grasses; but in perennial grasses more commonly underground or above ground stolons arise from the underground or above ground nodes. Each stolon may give rise to one or more seed-bearing culms, each with an independent root system. The latter in turn give rise to other stolons and culms.

The part arising from the node is of course a branch of the culm from which it grows; but it soon becomes a more or less independent plant by the roots which arise from a node of the branch more or less remote from the culm, or else in the case of rhizomes branches in turn arise from their nodes, which become seed-bearing culms. The point to note is that the habit of the plant, whether creeping or tufted, is dependent upon the distance the roots of the secondary culms are from those of the primary culm. The part between the two culms is called a stolon, whether occurring above, on, or underground, and when such part exists the plant is called stoloniferous. When the stolon is underground the leaves become modified into brown or colorless scales and the nodes are less pronounced, when it is known as a rhizome or rootstock.

Another difference may also be noted in the mode of growth. The branch arising at a node must of necessity arise in the axil of the leaf. The branch grows up within the leaf sheath, *intravaginal,* or it may bore its way through the base of the leaf which encloses it, *extravaginal.* Those plants which are tufted—such as orchard grass and perennial rye grass—belong to the former class. All strongly creeping plants—such as Kentucky blue grass, redtop, meadow foxtail, and smooth brome grass—belong to the latter. In timothy and meadow fescue the branches arise within the axil of the leaf sheath and subsequently break through. Plants that are strongly stoloniferous produce the densest sod and therefore the best pasture. On the other hand, this density of sod seems to interfere with the production of culms, and hence strongly stoloniferous plants in a few years produce small yields of hay.

A single timothy seedling at the Cornell Station produced 86 seed-bearing culms during the first summer of its growth and over 250 seed-bearing culms during the second summer. Fraser has shown that in timothy each corm and its accompanying roots die after producing a single seed-bearing culm. Grasses may, therefore, be kept alive as well as spread, by asexual or vegetative reproduction. Plants possessing this habit are counted by botanists as perennial; but it is evident that they are perennial in a different sense from that of a red clover plant, an alfalfa plant or a tree.

If we look upon each portion of a plant arising from a node and possessing separate roots as an individual, we may then say that the individual timothy plant does not, probably, produce fruit but once. It is obvious, therefore, that the duration of timothy is dependent upon those conditions which influence vegetative reproduction. Whether this is true of all grass plants it is perhaps not possible to state absolutely, but it seems

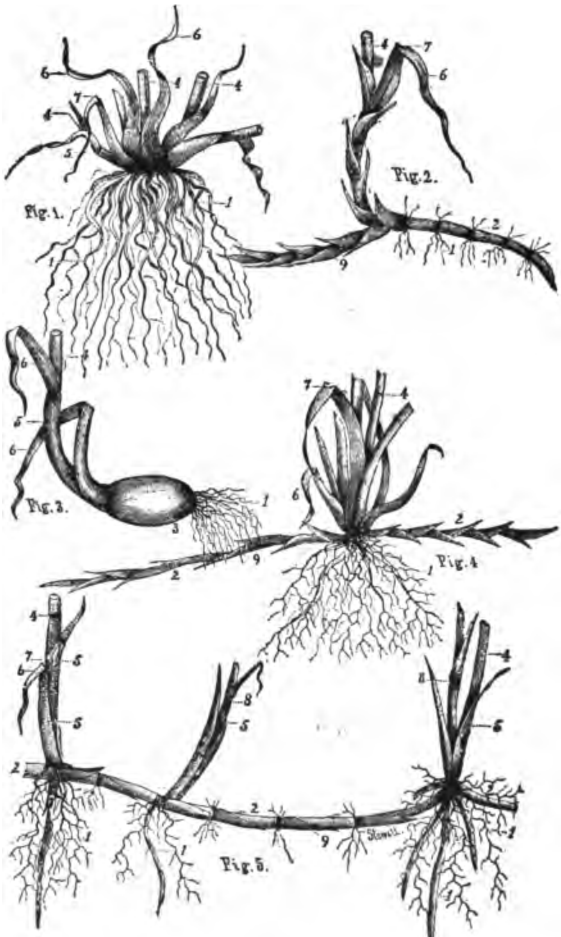


Fig. 1—1. Fibrous roots; 4. culm; 5. node; 6. leaf. Fig. 2—2. Rhizome; 4. culm; 6. blade of leaf; 7. ligule; 9. scales of the rhizome. Fig. 3—1. Root fibers; 3. bulbous base of culm; 4. culm; 5. sheath; 6. blade. Fig. 4-2. Scaly rhizomes; 4. node; 6. blade; 7. ligule; 9. scales of the rhizome. Fig. 5—1. Fibrous roots; 2. creeping rhizome; 4. culm; 5. sheath; 6. blade; 7. culm, 8. nodes.

(After Vasey)

probable that all plants of the grass family are monocarpic—that is, produce seed but once.

The duration of pastures and meadows may be influenced also by the opportunity which exists for grasses to produce seed freely. Pastures which are pastured too heavily often decrease in the thickness of the sod. It is a matter of observation that the duration of timothy meadows is shorter than formerly. This may be due to the practise of cutting timothy before the seed has formed, thus preventing re-seeding; or may be due to conditions less favorable to vegetative reproduction.

4. Common Characters.—Generally speaking, the cultivated grasses have the characters common to the grass family—namely, fibrous roots, jointed stems (nodes and internodes), two-ranked leaves consisting of sheath, blade, ligule, and auricle, one leaf arising from each node. Flowers are borne in spikelets, ovulary one-seeded, styles two, anthers usually three. (C. A. 52-58)

The cultivated grasses have certain characters common to each other but not common to all members of the grass family. They are perennial, grow during a considerable period of the year, produce but a small portion of their weight in seed which has little food value, have relatively a large amount of leaves to culms. The culms are rather small with relatively heavy walls. In grasses of economic value the surface of the leaves and stems is usually smooth. The essential characters which make grasses of economic value are yield, palatability, healthfulness, duration, prolificacy, and ease of curing.

5. Growing Point of Leaf.—The value of the grasses for grazing consists in a considerable measure in the large number of basal leaves and the manner of growth of the leaf blade. The growing point, which can usually be recognized by its lighter color, is at the base of the blade. The upper portion

The numbers in each of the figures are as follows: 1. Sheath; 2. blade; 3. culm; 4. node or joint; 5. ligule The ligule is best shown in the lower right hand figure (After Vasey) of the leaf blade may, therefore, be removed without injuring the growing part.

6. **Variations.**—While possessing certain characters in common, the different species of grasses not only vary widely from each other in habits of growth and minor botanical characters, but different individuals of the same species also vary widely; although less advantage has been taken of this fact to produce strains or varieties than in the case of the cereals. (53) (C. A. 37) Grasses vary in the depth of their root growth, smooth brome grass being deep-rooted and able to withstand drought; while Kentucky blue grass is shallow-rooted and liable to injury during dry weather,—which makes them adapted to different portions of the United States.

The strongly stoloniferous habit of Kentucky blue grass, redtop, and brome grass causes them to produce dense, even sod; while orchard grass grows in bunches and does not make an even sod. Timothy is somewhat variable in its stoloniferous habit, not only producing a less dense sod, but making its duration less certain. (50) In some cases the culms are erect, some decumbent, others are decumbent at the base only, while still others are kneed. The proportion of basal leaves to culm leaves, as well as the height of culm and its proportion as compared with the leaves, influences the yield and the quality of the hay.

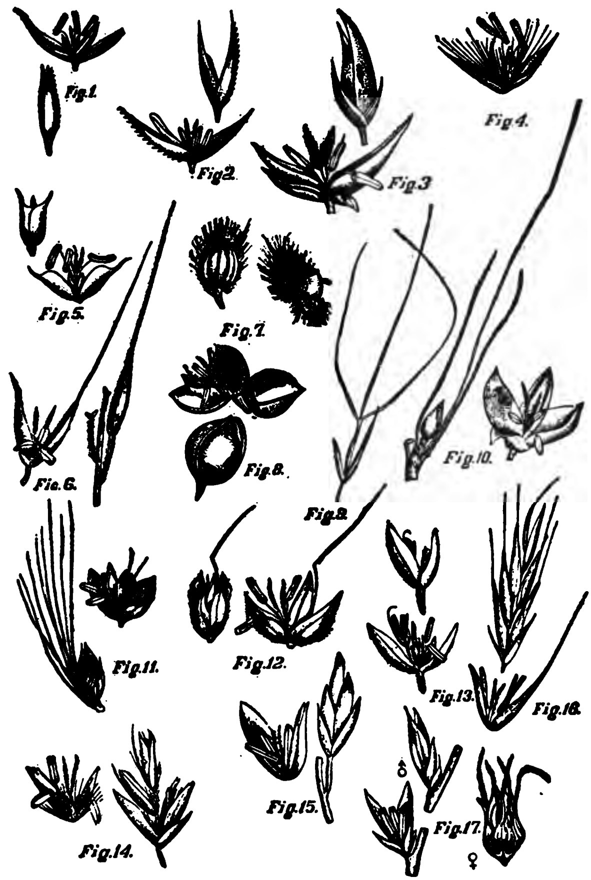
Certain characters serve to distinguish the grasses when not in flower. These are the size and thickness of the leaf blade, size and shape of the ligule, and the color of the basal leaf sheath. When in flower, the inflorescence is of course the chief method of distinguishing species. The inflorescence may be spike-like—as in the case of timothy and meadow foxtail, or a panicle—as in the case of redtop and Kentucky blue grass. Grasses are further distinguished by the number of flowers to a spikelet, the relative lengths of outer glumes, flowering glume,

1. A dense spike, *Alopecurus pratensis;* 2. An elongated, one-sided spike, *Paspalum dilatatum;* 3. Spike, *Hordeum pratense;* 4. Spike, *Agropyrum repens;* 5. Spike, *Elymus condensatus;* 6. Spike, *Bouteloua polystachya;* 7. Spike, *Bouteloua oligostachya;* 8. Panicle, *Panicum crus-galli;* 9. Panicle, *Agrostis exarata;* 10. Panicle, *Koeleria cristata;* 11. Panicle, *Distichlis maritima;* 12. Panicle, *Bromus secalinus;* 13. Panicle, *Hierochloa borealis;* 14. Panicle, *Poa pratensis;* 15. Panicle, *Dactylis glomerata.*
(After Vasey)

and palea, together with more minute characters. These will be found under the description of the individual grasses.

7. **Healthfulness.**—As pasture, all the cultivated grasses are equally healthful. There is not known to be any difference in the healthfulness of the different cultivated grasses, except such as occurs through curing. If the hay is fermented or dusty, it is objectionable—especially for horses. Certain legumes, however—such as alfalfa and red clover—cause cattle to bloat, especially if turned into a field when there is a heavy dew. Much less danger exists if the cattle are turned into the field when there is no dew or if they are left in the field continuously. Mixtures of grasses with either alfalfa or clover make them comparatively safe. Certain wild grasses—such as wild barley and darnel—are quite injurious. Alsike clover has been reported to be injurious sometimes. (178)

8. **Palatability.**—Although cultivated grasses vary little in healthfulness, they do vary considerably in palatability. Timothy is so highly prized that a small admixture of other cultivated grasses reduces the commercial grade. In practise this admixture is likely to be redtop, which either as hay or pasture is not as well liked by domestic animals as timothy. Kentucky blue grass is more palatable than Canadian blue grass or wire grass for pasture. For pasture, Kentucky blue grass, meadow foxtail, meadow fescue, and smooth brome grass excel in palatability redtop, orchard grass, and timothy. Tall oat grass and velvet grass are examples of grasses that are practically valueless on account of lack of palatability. Palatability also varies somewhat with the kind of animal. Sheep are said to be fond of orchard grass. They graze it close. The tramping keeps the grass from growing in bunches. Palatability may vary with soil and climate. Tall oat grass, which, in most parts of the United States, is considered unpalatable, is a highly prized grass in France. It has been suggested that this may



Forms of spikelets closed and opened. Fig. 1. *Agrostis vulgaris;* Fig. 2. *Agrostis exarata;* Fig. 3. *Sporobolus indicus;* Fig. 4. An opened spikelet of *Calamagrostis canadensis;* Fig. 5. *Phleum pratense;* Fig. 6. *Muhlenbergia diffusa;* Fig. 7. *Paspalum dilatatum;* Fig. 8. *Paspalum laede;* Fig. 9. A spikelet of *Aristida purpurea;* Fig. 10. *Setaria setosa;* Fig. 11. *Setaria glauca;* Fig. 12. *Alopecurus pratensis;* Fig. 13. *Holcus lanatus;* Fig. 14. A spikelet of *Deschampsia caespitosa* and one of its flowers; Fig. 15. A spikelet of *Poa serotina* and one of its flowers; Fig. 16. A spikelet of *Bromus erectus* and one of its flowers; Fig. 17. The staminate and pistillate spikelets of *Buchloe dactyloides*, the former both closed and opened.

(After Vasey)

be due to an abundance of some plant food, such as phosphoric acid.

9. Prolificacy.—An essential feature of a cultivated grass is that seed for sowing may be secured at a reasonable cost. This depends upon the number of seeds produced per plant, the usual percentage of germination, cost of harvesting and preparing for market, and the number of plants required per unit of area to secure a satisfactory stand. One of the most valuable characteristics of timothy is the fact that the seed required to sow an acre can be purchased for less than any other cultivated grass, because it produces seed abundantly, has high germinating power, is easily harvested and prepared for market, and a relatively small number of plants is required to produce a good stand. On the other hand, Kentucky blue grass seed is more difficult to harvest, greater care is required in preparing for market, and its power of germination as it occurs in commerce is much less.

The cultivation of certain grasses and clovers is practically prohibited because of the lack of prolificacy—as, for example, big blue stem (*Andropogon provincialis* Lam.), reed grass, zigzag clover, and *Trifolium pannonicum* Jacq. This latter is a perennial clover of apparently high value, were it not for the difficulty of securing seed.

10. Number of Plants Per Acre.—At the Cornell Station single plants of timothy when grown alone have given at a single cutting 1.25 pounds of well cured hay. Only 3,200 such plants would be required per acre to produce 2 tons of hay, or one plant to about every 14 square feet. There was obtained from 3,600 two-year-old plants at the Cornell Station a ton of hay, this being the number left from 7,200 plants on an acre, each 30 inches apart. When the minimum amount of timothy seed is sown per acre—namely, about 9 pounds—about 10,000,000 seeds are sown, or over 200 per square foot. Grass mixtures are sometimes prepared on the basis of 20,000,000 viable seeds per acre.

There are three sources of loss. Some seeds never germinate, some plants die from lack of suitable conditions—as, for example, through shallow sowing, and some plants are crowded out by their more vigorous neighbors. If possible, it would be desirable to eliminate the first two sources of loss; but in so far as the plants fail to survive because they are less vigorous or less hardy than their neighbors, the result is beneficial. While in ordinary practise loss usually, perhaps, occurs both from lack of number of plants and lack of uniformity of stand, it is possible that with certain grasses having a strongly stoloniferous habit too great crowding may occur. It has been noticed that in certain regions some grasses—such as smooth brome grass—produce hay abundantly for two or three years after seeding, but as a dense sod forms the production of hay becomes less.

11. Composition.—The analyses of the hay of perennial forage grasses do not indicate striking differences in the composition of different species. The composition of the hay of the same species at different stages of maturity may vary as greatly as that of different species; so that the average composition as given in the table below may be due as much to the stage of maturity and the methods of curing and handling as to any inherent differences in the grasses. Naturally, therefore, analyses of different species have been of little value in determining their feeding value. The feeding value depends largely on the palatability and freedom from injurious effects. Palatability depends largely on aroma, flavor, smoothness of parts, and freedom from dust. The table on page 14 gives American analyses of the common and some less common grasses.

Compared with the grains and other concentrated foods, the hay of perennial forage grasses is low in protein and fat and

Table Giving American Analyses of Some Common Grasses

Name of plant	Number of analyses	Water	Ash	Protein Nx 6.25	Crude fiber	Nitrogen-free extract	Fat
Bermuda grass	..	14.3	7.8	11.5	20.0	45.1	1.3
Blue joint	..	6.9	5.5	11.2	37.2	35.8	3.4
Canada blue grass	..	14.3	4.5	7.6	21.7	49.0	2.9
Couch grass	5	14.3	6.0	8.8	24.8	43.1	3.0
Crab grass	..	14.3	10.8	8.4	27.5	36.6	2.4
Fowl meadow grass	..	14.3	3.6	5.4	17.9	56.4	2.4
Gama grass	..	14.3	5.3	7.4	22.7	48.3	2.0
Hungarian grass	12	7.7	6.0	7.5	27.7	49.0	2.1
Italian rye grass	..	9.3	6.7	8.8	28.4	44.9	1.9
Johnson grass	..	14.3	6.9	10.9	21.5	44.8	2.4
Kentucky blue grass	4	24.4	7.0	6.3	24.5	34.2	3.6
Meadow fescue	..	14.3	7.8	9.2	20.8	45.1	2.8
Meadow foxtail	..	6.6	9.8	9.3	32.3	38.9	3.1
Orchard grass	10	9.9	6.0	8.1	32.4	41.0	2.6
Perennial rye grass	..	14.3	5.2	7.6	35.7	54.8	2.4
Redtop	9	8.9	5.2	7.9	28.6	47.4	1.9
Schrader's brome grass	..	14.3	8.4	11.7	17.6	44.9	3.1
Sheep's fescue	..	7.4	6.8	6.0	33.1	43.9	2.8
Smooth brome grass	..	6.2	7.6	10.1	38.7	35.5	1.9
Sweet vernal grass	..	14.3	5.0	9.9	21.9	46.4	2.5
Tall meadow oat grass	..	10.7	5.0	8.7	27.8	44.5	3.3
Texas blue grass	..	14.3	10.0	9.1	27.3	36.1	3.2
Timothy	68	13.2	4.4	5.9	29.0	45.0	2.5

high in crude fiber. Neither the digestible fat (ether extract) nor the digestible nitrogen-free extract in hay is as valuable for feeding purposes as equal quantities in the grains. Compared with the leguminous forage plants, the hay of grasses is much lower in protein, but otherwise does not differ greatly except in so far as is made necessary through the lower protein content.

12. Digestibility.—Comparatively few digestion experiments have been made with the hay of the perennial forage grasses, but it is generally conceded that the coefficient of digestion for one species of grass will apply fairly to another if both are harvested at proper stages of maturity and cured in a similar manner. In a general way, 75 to 90 per cent. of the dry matter of grains and other concentrates is digested by ruminants, 50 to 65 per cent. of the hay of grasses and legumes, and 40 to 50 per cent. of the straw of cereals.

The net nutritive value of hay is much less than that of grains, not only because it contains less percentage of digestible nutrients, but also because a larger proportion of the energy is used in masticating and digesting the hay. The energy being thus used is not available for the production of work, flesh, or milk. The energy of mastication and digestion manifests itself in heat, however, and helps to keep the animal warm. Hay and straw may, therefore, be used in wintering mature animals when they would not be useful when used alone for work or for growing animals or for the production of milk. As illustrating the differences in net nutritive value of different foods when fed to horses, the trials by Zuntz and Hagermann, of Germany, are given on the next page.[1]

II. SEEDS AND MIXTURES

13. Quality of Seed.—No factor, perhaps, has a greater influence on the economic use of forage plants, whether grasses or legumes, than the quantity and the quality of the seed produced. Apart from its hereditary power, the quality of seed is determined by the purity, the germinating power, the size of the seed, and the weight per bushel. The higher the purity, germination and weight per bushel, and the larger the grain, the more valuable the seed. In some instances—as, for ex-

[1] Landw. Jahrb., 27 (1898), No. 3, pp. 440.

Table Showing True Nutritive Value of Different Feeding Stuffs

Feeding stuffs	Dry matter	Total digestible nutrients	Labor expended in chewing and digestion in terms of nutrients	True nutritive value in terms of nutrients
	Per cent.	Per cent.	Per cent.	Per cent.
Medium hay (average quality)	85	39	21	18
Alfalfa hay cut at beginning of bloom	84	45	22	23
Red clover hay	84	41	24	17
Winter wheatstraw	86	18	30	—12
Oats (medium quality)	87	61	12	49
Maize	87	78	8	70
Field beans	86	72	11	61
Peas	86	69	10	59
Linseed cake	88	69	13	56
Potatoes	25	23	3	20
Carrots	15	11	2	9

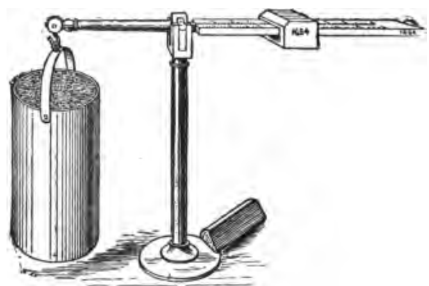
ample, with red clover and alfalfa—the origin of the seed may be a matter of importance.

Seed control stations determine the kinds and percentages of impurities and the power of germination—that is, the percentage of pure seeds which can germinate or grow.[1] The percentage of viable pure seed is obtained by multiplying the percentage of pure seed by the percentage of total germination of the pure seed. This is sometimes spoken of as the actual value of the sample. A sample, however, that contains 90 per cent. of viable pure seed may be relatively more valuable than a sample containing 80 per cent. than is indicated by 90:80, because of the more vigorous growth of seeds of high ger-

[1] For example of pure seed law, see Maine Station Report, 1896, p. 181; or, Bul. No. 36 (1897), p. 65.

minating power. On the other hand, a sample with the higher percentage of viable pure seed may be less desirable to sow because of the kind of impurities.

14. Weight per Bushel.—While the sale of seed by the hundredweight is gradually superseding sale by the bushel. nevertheless weight per bushel is an excellent guide to the number of seeds per pound, since the freer the seed is from chaff the higher the weight per bushel. In the table on page 18 the extreme variations in actual weight per bushel, as reported by different stations and other authorities, are given in the first column; while in the second column occurs the legal weight in Canada and the several states where such legal standards exist.



Scales for determining the weight per bushel of seeds

15. Impurities.—These may consist of three classes: (1) inert matter, (2) weed seeds, and (3) foreign but useful seeds. Impurities may be accidental—namely, due to the imperfection of cleaning machinery and to the occurrence of weeds or cultivated plants in the crop when harvested. Adulterants or foreign bodies artificially added for gain may consist of inert bodies—such as colored stones in red clover seed, or seeds of plants of greater or less usefulness but of less cost per pound—such as black medic seed in red clover, Canada blue grass for Kentucky blue grass, and perennial rye grass for meadow fescue seed. In some cases complete substitution is made. In general, grass seeds have not been subject to a great deal of adulteration. The purpose of many lawn grass mixtures, however, is to substitute lower priced for higher priced seeds. Alfalfa and clover seeds have been rather more subject to

Table Showing Weight per Bushel of Grass Seed in Pounds

Name of grass	Extreme weights per bushel	Legal weight per bushel
Barnyard millet, Japanese	35	35
Bermuda	36	..
Blue joint	14	..
Broom corn millet	60	..
Canada blue	14 —20	..
Creeping bent	15 —20	..
Crested dog's tail	26 —30	..
Fowl meadow	12 —15	..
Italian rye	17 —24	20
Johnson	28	28
Kentucky blue	13.25—28	14
Meadow fescue	12 —28	..
Meadow foxtail	5.25—14	..
Millets[1]	50	50[2]
Orchard	11.5 —21	14
Perennial rye	18 —30	..
Redtop	12 —40	14[3]
Reed canary	14 —48	..
Rhode Island bent	15	..
Rough stalked meadow	11 —28	..
Sheep's fescue	12 —28	..
Smooth brome	12 —14	14
Sweet vernal	6 —15	..
Tall meadow fescue	14 —25	..
Tall meadow oat	7 —14	7
Timothy	44 —50	45[4]
Velvet	6 — 7	7

[1] Common, Hungarian, German, Golden Wonder.
[2] Reported for "millet" in a number of states; 48 lb. in Minnesota.
[3] 12 in Virginia.
[4] 48 in Canada, 42 in Oklahoma, 60 in Arkansas.

adulteration. The most important impurities are noxious weed seeds, their injurious quality being due to the kinds rather than the quantity of seeds present. A great deal of seed placed on the market is of low germinating power.

16. Sampling Seeds.—It is essential to secure an average sample of seed to be tested either for impurities or for germination. If the seed is in a bin, a grain sampler may be used; if in sacks, samples may be taken from various parts of each by means of small seed sampler. When the quantity is small enough, it should be emptied upon a flat surface, thoroughly mixed, and seeds taken from various parts to make up the sample for mixing. For the seeds of forage crops, either of grasses or of legumes, a two-ounce sample is sufficient, except where the seeds are the size of vetches or cowpeas, when a four-ounce sample should be taken.

Seed mixer and sampler

In testing grass seed it is essential to take small and large seeds in the proportion in which they exist in the whole sample. In some grass seeds there are many empty glumes which it is difficult to distinguish from those containing grain. They may be distinguished by wetting the seeds, placing them upon a plate of glass and holding up to the light, when the empty glumes will appear translucent, while those containing seed will be opaque.

The sample as received for testing may be spread carefully upon a sheet of paper and divided by means of a spatula into sub-divisions until a small enough sample for actual test is obtained. Or it may be done as in the seed-testing division of the United States Department of Agriculture, by means of the apparatus shown in this paragraph.

17. Seed Identification.—As grass seeds occur in commerce, the seeds are usually surrounded by the flowering glume and palea, although a portion of the sample may contain naked seeds. The naked seed is the ripened ovulary or fruit known as a caryopsis, as in the case of cereal seeds. (C. A. 6b) The flowering glume furnishes means of identification by variations in length, color, and thickness, character or absence of keel, number of nerves, character of position and shape of awn; by the shape, position, and hairiness of the rachilla, or by its absence. When the spikelet is two—or more—seeded the rachilla exists; but when, as in timothy and redtop, the spikelet is one-seeded, no rachilla is attached at the base of the palea in the harvested seed. The point of the flowering glume may be blunt or pointed, and may be straight or curved.

In the case of the seeds of the legumes the general shape and, to some extent, the color and size of seeds furnish means of identification. The relative length of the ridge or raphe, the prominence of the tip of the caulicle or radicle, and the shape and color of the hilum are often characteristic. The pods when present are one of the most certain means of identification.

18. Germination of Seeds.—The practise of seed control stations is to germinate seeds at a temperature of 64° to 68° F. The practise with regard to grass seeds is to raise the temperature during six of the 24 hours to 86° F., as this temperature has been found to promote germination. Kentucky blue grass has been found to germinate better when the temperature is lowered to 40° F. a portion of the 24 hours. The time required to test most grass seed has been established at 21 days, timothy and rye grass 14 days, while for the Poas 28 days are required. Legumes require about seven days. Among leguminous seeds, especially clover seeds, the presence of hard or dormant seeds is common. On account of the structure of their seed coats or of their chemical composition, they do not readily absorb water and hence do not germinate within seven days, although they do so later. It is usual to add one-half to one-third the per cent. of hard seeds remaining to the percentage of germinating seeds. In red clover the number of hard seeds is generally 7 to 9 per cent. They are said to be more common when the seed crop is good and to be more frequent among dark clover seeds. It has been found that scratching or rubbing the surface makes them more easily germinable, and it is said that friction is sometimes practised by seedsmen for this purpose.

Germination tests are carried on either between or upon flannel cloth or blotting paper or in beds of sterilized sand free from organic matter. The small seeds do best when placed upon, the large ones when placed between the media. Experience has shown which gives the best results in the case of each species. In seed control stations the seeds from 100 to 400, after being placed upon or between the cloth or blotter, are put in a germinating apparatus where the temperature is under control. (C. A. 476) For private tests the cloth, blotter, or sand may be placed between dinner plates, kept in a room that does not fall below 50° F. at night and is between 60° and 70° F. during the day.

19. Grass Mixtures.—The desirability of sowing two or more kinds of grass seed together must depend largely on the adaptability of the grasses to the locality and the purpose for which the crop is grown. For hay the plants should mature at about the same time. It may be laid down as a rule that for hay it does not pay to grow one plant with another when it is not in itself adapted to the conditions under which it is grown when sown alone. If it does not pay to sow alone it will not pay to sow with another crop. The introduction of such a plant reduces the yield by occupying land which could have been more profitably occupied by a plant adapted to the existing conditions. The plant is out of place; it becomes a weed.

Roots never fully occupy the soil. Those of different plants occupy different portions of it. The roots of timothy grow near the surface; clover roots grow deeper. Thus to a certain extent they do not interfere with each other. When red clover is sown with timothy the former usually dies after the second crop, leaving the decaying roots and stems to furnish their acquired fertility to the timothy and to succeeding crops. The holes left by the decaying roots may perhaps in some cases improve the mechanical condition of the soil. In many fields some portions of the land are best adapted to timothy and other portions best adapted to red clover. Under these conditions a combination may yield the maximum crop.

In some localities timothy does not reach its best development until it has been sown two or three years. In the meantime the clover may occupy a portion of the ground with no serious ultimate disadvantage, apparently, to the timothy. The seeding with a miscellaneous mixture of grass seeds of varieties of little or no value when sown alone has neither practical nor experimental evidence in this country to commend it. Under uniform conditions of soil, the maximum yields of hay are obtained when but a single species exists. For pasturage, several varieties may be desirable in order to furnish a succession of herbage throughout the season. The chief difficulty in America is to find varieties adapted to our soil and climate which will do this. (74)

20. Calculating Mixtures.—The amount of seed required per acre may be stated in the number of pounds of viable pure seeds or as the number of pounds of commercial seed of a stated percentage of purity and standard of germination. In this volume the latter mode of statement is employed.

In order to secure a stand containing a desired percentage of different species of grasses and legumes, it is necessary to sow the same percentages of the amount of seed required for a complete stand when sown alone, making such correction as may be necessary on account of difference in percentage of viable pure seed. Further, an additional amount of seed, varying from 10 to 80 per cent., is added because of the ability of the land to support more plants when two or more species are sown together. As an illustration, let it be supposed that 15 pounds of timothy seed containing 88 per cent. of viable pure seed, 10 pounds of red clover seed containing 95 per cent. of viable pure seed, and 8 pounds of alsike clover containing 90 per cent. of viable pure seed are required when sown alone, and that a mixture is desired consisting of 50 per cent. timothy, 25 per cent. each of red and alsike clover, and the per cent. of viable pure seed in the commercial samples to be used are 80, 90, and 85 respectively, and that a stand of 50 per cent. greater is possible on account of the mixture,—the amount of seed required will be shown in the following table:

The plant	Commercial seed of standard quality	Viable pure seed	Commercial seed of quality purchased	Amount required on addition of 50 per cent.
	Lb.	Lb.	Lb.	Lb.
Timothy	7.	6.6	8.25	12.37
Red clover	2.5	2.38	2.64	3.96
Alsike clover	2.0	1.8	2.12	3.18

21. Pasture Grasses.—A considerable portion of the live stock of the United States has thus far pastured upon lands which have never been seeded by man, while frequently those which have at some time been seeded now contain chiefly grasses that were not sown. In the western half of the United States domestic animals graze principally upon the native grasses.

chief of which are the grama, the mesquite, buffalo grass, and the bunch grasses of which those belonging to the genus *Stipa* and to the genus *Oryzopsis* are the leading types. Likewise, *Koeleria cristata* ((L.) Pers.), *Deschampsia caespitosa* ((L.) Beauv.), and several species of the genus *Festuca* are widely diffused. Blue joint (*Calamagrostis canadensis* Beauv.) is one of the best and most productive on moist soils and in cool climates. The native grasses of the range have the common characteristics of growing in a dry climate and producing a nutritious herbage which retains its nutritious qualities when dried standing. This is in part due to the climate rather than to the kind of grasses. The latter quality is probably in part due to the fact that fermentative and putrefactive qualities of all kinds take place less rapidly in a dry than in a moist climate. East of the Missouri River and north of the cotton states the *Poas,* of which Kentucky blue grass is the most common species, form with white clover the basis of most all pastures. In some sections, notably the New England states, the *Agrostis,* of which redtop is a common species, form no inconsiderable part of the herbage. In places, especially upon good land, the fescues occur, particularly the meadow fescue. Meadow foxtail occurs in slight quantities. When seeding to pasture, timothy generally forms a part of the mixture because of its rapid growth. Where conditions are favorable, orchard grass makes fairly satisfactory pasture. (85) Smooth brome grass, introduced as late as 1896, is being highly recommended as a pasture grass for sub-humid sections of the United States. Bermuda grass has been introduced into the cotton states, where with Japan clover it is somewhat, although not extensively, used for pasture.

22. Native Grasses.—Gradually the settlement of new lands and the changes from the range to improved agriculture are replacing the native prairie grasses with cereals and tame grasses. Nevertheless, the area in wild, salt, and prairie grasses in 1899 constituted nearly one-fourth of the total acreage producing hay and forage. The great bulk—four-fifths—of this production was confined to the North Central states, forming a distinct western border to timothy culture. These grasses are supplied by a considerable number of tribes of the grass family, but come principally from seven tribes, of which the most important are probably the *Chlorideae,* furnishing blue or white grama (*Bouteloua oligostachya* (Nutt.) Torr.), the *Andropogoneae,* furnishing big blue stem (*Andropogon provincialis* Lam.), and the *Hordeae,* furnishing western wheat grass (*Agropyron spicatum* (Pursh) Scribn. & Smith).[1]

23. Influence of Species of Plants on Value of Pasture.—A grass or other plant in a mixed herbage is no evidence of its value, since its occurrence may be due to the failure of animals to eat it readily. (8) In America, blue grass is widely prized as a pasture grass; while stock men generally look upon wire grass or Canadian blue grass as a weed and as having little food value. Certain observations, however, seem to indicate that although wire grass is likely to occur on less productive land, and therefore to support fewer animals per acre, cattle can be fattened upon it.

With the view to determining the relative value of different species of grasses and of different species of plants other than

[1] These tribes together furnish, among others, 16 species of rather well established economic importance. They are as follows:

Andropogoneae: big blue stem (*Andropogon provincialis* Lam.), little blue stem (*A. Scoparius* Michx.), bushy blue stem (*A. nutans* L.), broom sedge (*A. virginicus* L.); *Zoysieae:* black bunch grass or black grama (*Hilaria mutica* (Buck.) Benth.); *Paniceae:* munro-grass (*Panicum agrostoides* Muhl.); *Agrostideae:* wild timothy (*Muhlenbergia racemosa* (Michx.) B. S. P.), wire grama (*M. porteri* Scribn.), saccaton or maton (*Sporobolus wrightii* Munro); *Festuceae:* salt grass (*Distichlis spicata* (L.) Greene), reed meadow grass (*Panicularia americana* (Torr.) MacM.); *Chlorideae:* blue or white grama (*Bouteloua oligostachya* (Nutt.) Torr.); side oats (*B. curtipendula* (Mx.) Torr.); *Hordeae:* giant rye grass (*Elymus condensatus* Presl.), western wheat grass (*Agropyron spicatum* (Pursh) Scribn. & Smith), western couch grass (*A. pseudorepens* Scribn. & Smith).

grasses upon the permanent pastures of England, the Royal Agricultural Society appointed a commission which, after investigating the subject for several years, reported that in different pastures the species of cultivated grasses ranged from 11 to 100 per cent., of legumes from zero to 38 per cent., and miscellaneous plants, so-called weeds, from zero to 89 per cent. No correlation whatever was found between the value of the pasture as shown by the beef and mutton produced and the botanical character of the herbage. Pastures with widely varying proportions of grasses and other plants produced equally good results; while pastures with the same percentages of different grasses and other plants gave widely different results.

24. Collateral Reading.—W. J. Beal: Grasses of North America, Vol. I, pp. 5-13; 75-78. New York: Henry Holt & Co., 1896.

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C. A. Zavitz: Permanent Pasture. In Ontario Agr. Col. and Expt. Farm Report 1893, pp. 110-117.

II

PERENNIAL FORAGE GRASSES

I. CULTURAL METHODS

25. Nurse Crop.—The usual method of sowing grass seed is to sow with grain crops. Undoubtedly this is good practise for most regions. Usually no crop of hay can be harvested the first year. If sown alone the land is not sufficiently shaded by the grass to prevent the growth of weeds, which otherwise must be mown at considerable expense. The crop of hay the succeeding year is no better than if grain had been sown with the crop the preceding year. This is especially true of our leading hay crops—timothy, red clover, mammoth red clover, and redtop. A crop of grain, also, is obtained at little additional expense. The New Hampshire Station[1] conducted an experiment in seeding meadow with nurse crop versus no nurse crop. The hay crop consisted of a mixture of 17 pounds of grass seed and 12 pounds of clover seed per acre, while barley served as a nurse crop. Although the yield from that portion of the field sown with barley greatly exceeded that without barley the first season, the yield the second season was distinctly in favor of that portion where no nurse crop had been sown. Nevertheless the total weights for the two seasons showed an excess of 1.8 tons in favor of the crop sown with barley. Whether or not the relative yields would remain constant, had the experiment been continued, the indications are that for New Hampshire conditions the nurse crop is advisable.

In some regions, however, timothy sown alone in fall will

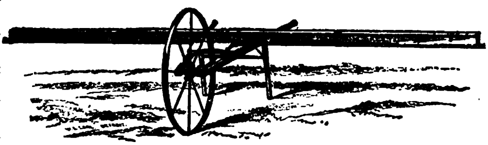
[1] New Hampshire Sta. Bul. No. 59 (1898), p. 186.

produce a fair crop of hay the following season. Under such conditions, when sown with wheat, it produces so much hay as to interfere with the harvesting of the crop as well as materially to reduce the yield of wheat. In such regions the custom is either to sow the timothy alone or sow it later—say ten days after wheat has been sown. These localities are the exception rather than the rule. Generally the practise of sowing the grass seed with the grain crop is based on sound business principles.

26. Method of Seeding.—Grass seeds may be sown by hand; and with certain chaffy seeds, such as uncleaned redtop, uncleaned Kentucky blue grass, or smooth brome grass seeds, this is the only satisfactory method. For timothy, re-cleaned redtop, recleaned Kentucky blue grass, the clovers and alfalfa, grass seeders give more satisfactory results. The grass seeder which throws the seed from a revolving disk may be used under a greater variety of conditions, but the evenness of seeding is more affected by the wind than when the so-called wheelbarrow seeder is used. Grass seeders are also attached to grain drills, and when grass seed is to be sown at the same time as the grain this is the most satisfactory method of sowing. The spouts are generally adjustable so that seeds may be sown in front or behind the grain hoes, thus making it possible to vary the depth of seeding, depending on the character of the soil or the kind of seed.

Hand seeder

27. Time of Seeding.—Grasses may be successfully sown at any portion of the growing season, but in humid climates fall sowing is usually the most successful, either when sown alone or with grain crops, as is the most usual practise. Sowing with fall crops gives better results, not only because germination is usually more certain but because fall cereals are usually harvested earlier than spring cereals; consequently less injury results to the new seeding after the harvesting of the cereal, which is frequently a critical period for the grass. In sub-humid sections where there is almost no fall precipitation, spring seeding becomes desirable, since if sown in the autumn the seeds germinate poorly or not at all, and the growth is unsatisfactory. Autumn seeding is therefore not practised in such sections.



Wheelbarrow grass seeder

28. Depth of Seeding.—Grass seeds must not be sown so deeply as cereals. The smaller the seeds the shallower they must be sown. They have less starch with which to support the plant until the germination is complete. The plant is so delicate that it cannot overcome the resistance of the soil. These facts make a well-prepared seedbed or a great waste of seed imperative.

Much seed is sown without any covering, although a light covering is generally advantageous. Probably better average results would be obtained with deeper covering than is usually practised, if the seedbed is carefully prepared. In continued moist, rainy weather the covering is not important. The great difficulty in securing a stand is from the drying of the surface soil just when the seeds are sprouting and the plants are becoming established. The seeds being so near the surface the soil may in a few days become dry enough to kill the plants.

29. Rotations.—Rotations have usually been studied from the standpoint of the influence of the grasses in improving the soil for other crops rather than to secure the best rotation for the grass. (C. A. 283) It has long been recognized that grass is an important factor in a proper system of husbandry. There is an old Flemish proverb: "No grass, no cattle; no cattle, no manure; no manure, no crops." Both scientific research and farm practise confirm this proverb.

Aside from the value of a rotation including grasses for improving the crop-producing power of the soil, it is desirable to plow up meadows and put the land into other crops for the benefit of the meadows themselves. Insect enemies increase from year to year. Weeds that produce seeds before the grass is mown also increase. At the Cornell Station, out of 9,000 plants that had been grown separately 49.4 per cent. died during the first two years after they had started. In field practise the increasing compactness of the soil and the decreasing aeration would both probably tend to reduce reproduction by underground stems and therefore reduce the life of the meadow. Whether succeeding generations of plants reproduced asexually by the underground stems are weaker than those plants produced by seed has not been shown experimentally. The fact that English pastures have remained permanently in grass for 300 years suggests that asexual reproduction does not weaken the vitality, although in these cases some re-seeding has doubtless occurred.

In some instances a timothy meadow reaches its best development the second year after seeding—or, in other words, the largest yield of hay is obtained at the first cutting. Taking the region adapted to the growth of timothy as a whole, however, it is probable that the best yields are obtained at the second and third cuttings, or on the third and fourth years from seeding. Either when sown alone or in combination with red clover, therefore, a rotation in which timothy occupies two or three crop years will give usually the best results so far as the yield of hay is concerned, and probably also so far as increasing the power of the soil to produce other crops. When variations are made from this period it is usually due to economic conditions—as the difficulty of plowing the land, and the relative adaptability or value of different crops. Beginning with land which would hardly produce 500 pounds of hay to the acre, the Rhode Island Station—by means of a six-course rotation consisting of rye one year; grass (timothy 15, redtop 7.5, red clover 7.5 pounds) three years; maize one year; and potatoes one year; and by means of rather heavy applications of commercial fertilizers each year, and the use of lime—has secured hay crops averaging 4 tons or more per acre.

Land used for pasture is often the least arable portion of the farm and, in such case, not likely to enter into the general system of rotation. When it does enter into the rotation, different grasses are required than when the pasture is permanent. It is not advisable to sow Kentucky blue grass, meadow fescue, or meadow foxtail unless the land is to remain in pasture for more than three years. Where, from lack of adaptation of suitable grasses for pasture, it is necessary to use grasses and clovers of short duration, then pastures, like meadows, must be renewed by plowing and re-seeding.

With suitable grasses, pastures may be permanent. In England pastures are believed to improve with age, pastures having existed there for such long periods that there is no record of the land having been plowed, although the existence of furrows is evidence that they have been. While pastures may be permanent, a rotation of crops may occur. Not only may different species occupy the same spot at different times, but the proportion of different species will vary with climatic and soil conditions.

30. Fertilizing Elements.—Experiments by Lawes and Gilbert conducted on a large scale and extending over many years show that nitrogenous manures act most beneficially on grasses, while potash manures are most beneficial to leguminous plants. While the results of American stations tend to confirm the principles involved in the English experiments, the results in practise are somewhat masked by the fact that American soils are on an average relatively more virgin and hence presumably better supplied with soluble nitrates, and over a wide area in America the soils are relatively low in phosphates. In America, phosphoric manures frequently have a marked influence upon vegetative growth, especially when used in connection with nitrogenous manures for grasses and potash manures for leguminous crops.

31. Essential Conditions for the Successful Use of Fertilizers upon Grasses.—There are three conditions necessary for a successful increase of a grass crop through the use of fertilizers of any sort:

1. The increase will depend on the ability of the land to grow a crop without fertilizers. If the land will now grow only 1,000 pounds of hay to the acre and this small growth is due primarily to the need of fertilizers, then a certain application of fertilizer may increase the yield to 4,000 pounds per acre. If the same application is made to land already yielding 4,000 pounds of hay per acre, the increase may or may not be 3,000 pounds per acre, depending on whether 7,000 pounds are a normal yield with the climatic conditions of the place and the stand of grass.

2. The increase due to fertilizers depends on the climatic conditions. If the climatic conditions are such as to produce only 1,000 pounds of hay per acre, the addition of fertilizers will not materially increase the yield. If the climatic conditions are such as to produce 7,000 pounds of hay per acre, it may take less fertilizer to increase the yield from 4,000 to 7,000 pounds per acre than from 1,000 to 4,000 pounds per acre.

3. Where the climatic conditions are favorable, grasses respond well to the use of fertilizers; doubtless due, in part at least, to the large number of plants influenced by the fertilizers and to large root surface which prevents the loss of the fertilizers applied. An essential condition, therefore, for a

maximum yield is a sufficient and uniform stand of the grass or grasses it is desired to grow. It is true that under favorable conditions a comparatively few plants may produce a large yield. (10)

There are probably two reasons why a large stand is desirable. There is a limit to which a single plant may be increased through the use of a fertilizer, and hence the larger the number of plants within certain limits the greater the total increase. The second reason may be found in the fact that when the plants are not sufficiently thick, other less desirable and smaller yielding plants grow. By occupying the space and by taking the available plant food at critical times such grasses reduce the yield.

The principles here enunciated are of great practical importance in America. Over a large area, especially in the North Central, the Western, and the Southern states, the chief limiting factor in the production of perennial forage grasses is the climatic conditions. The production of timothy is limited to two tons per acre or less, principally by climatic conditions. The addition of fertilizers, except in so far as they may change the moisture content of the soil, is not likely to have material effect in increasing the yield, although an increased vigor of plants induced by fertilizers during a moist period may have some effect. On the other hand, throughout the northeastern part of the United States the climatic conditions are extremely favorable to the growth of grasses. The very climatic conditions which are favorable to the growth of grasses are also favorable to a waste of the available plant food of the soil; thus it is here that experimental evidence shows marked influence from the use of fertilizers when applied to grass lands.

Commercially, two other factors enter into the use of fertilizers—namely, the cost of the fertilizers and the cost of the product. Since the cost of transportation is high on both the fertilizer and the hay, it results that local conditions will more largely influence the use of fertilizers, and especially commercial fertilizers, upon the perennial forage grasses than upon any other of our staple crops.

The cumulative effect of adding commercial fertilizers year after year to perennial forage grasses is probably greater than with annual crops of any kind. This is probably not due alone or even principally to the cumulative effect of the plant food in the soil, but to the more vigorous plants which are carried over from year to year. One of the effects, doubtless, is to increase the duration of the plant and thus prevent the entrance of other less desirable and less productive plants.

32. Application of Commercial Fertilizers.—Commercial fertilizers, when applied to pastures or meadows, should be applied in the spring as soon as the grass starts to grow. Experiments indicate that one such application is as effective as the same quantity of fertilizer divided between two or more applications throughout the season. The fertilizer may be sown by hand, although there are distributers for broadcasting fertilizers. The Cornell Station advises for application to timothy meadows on Dunkirk clay loam, when in proper rotation, 200 pounds of nitrate of soda, 100 pounds of 15 per cent. acid phosphate, and 50 pounds of muriate of potash per acre. This is equal to the application of 250 pounds of a 15-6-10 mixed fertilizer per acre. The Rhode Island Station in a six-course rotation—maize on grass sod, potatoes, winter rye, each one year; red clover and grass (timothy and redtop), three years—recommends an annual application of the following fertilizers as a top-dressing to the grass: nitrate of soda 350, muriate of potash 200, acid phosphate 500 pounds.[1]

33. Methods of Improving Pastures.—Pastures may be improved in four different ways:

[1] Rhode Island Sta. Bul. No. 99 (1904), p. 107.

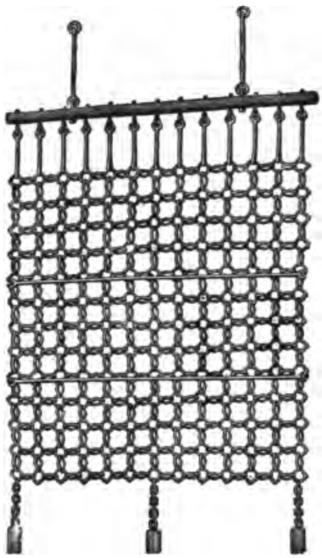
1. By sowing upon the pasture from time to time moderate quantities of a suitable mixture of grass seeds. This is especially desirable in case fields are kept closely pastured and thus not allowed to re-seed.

2. Although it may slightly decrease the palatability of the grass for the time being, the spreading of stable manure is a means of greatly improving the productivity of a pasture. Where stable manure is not available commercial fertilizers may be used. For the North Atlantic states nitrogenous fertilizers generally give the best results; but for the North Central states fertilizers containing phosphoric acid as well as nitrogen should be used.

Continued pasturage by cattle not otherwise fed may slowly reduce the fertility of the soil. Fattening animals on pasture or feeding grain to milch cows while on pasture increases the fertility of the soil by returning more to it than is taken from it. Experiments have been made by Lawes and Gilbert which show that different fertilizers have very different effects on different grasses and clovers. They find that the most complex herbage occurs on unmanured land, that potash and phosphoric acid increase the proportion of leguminous plants, and that nitrogen and green manure increase the proportion of grasses. The yield of hay was increased more by the use of stable manure and nitrogen than by the use of phosphoric acid and potassium. It is evident that with different kinds of fertilizers favoring different kinds of plants, the character as well as the kind of pasture may be influenced by the character of the food fed the stock which feed upon the pasture. The kind or purpose for which the stock is used may affect the pasture for a similar reason.

3. Pastures may be improved by harrowing, which may be done with a spike tooth or chain harrow in order to spread the droppings of the cattle, thus not only increasing the production of grass but also its palatability. This may be done during

rainy periods when it is not possible to use the teams on arable land, while the harrowing is most effectively done at such times.

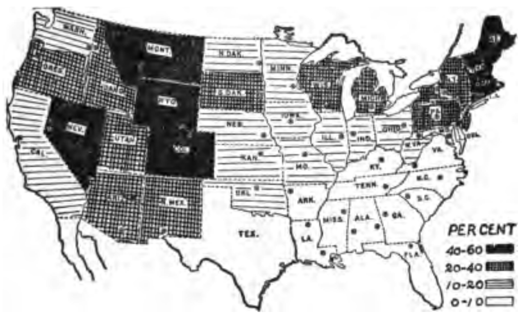


Chain barrow used in England for improving pastures

4. Pastures may also in some cases be improved by clipping with the mowing-machine where weeds are likely to go to seed or where from want of sufficient pasturage the grasses become woody and unpalatable. Clipping, however, is likely to reduce the amount of pasturage for the time being, and where pasture is scarce may not be advisable.

II. PRODUCTION AND HARVESTING

34. Distribution and Adaptation.—So far as the cultivated grasses have yet been extensively introduced, they have been found best adapted to that portion of the United States east of the Missouri River and north of the cotton states. While there are certain exceptions where limestone soils exist—such as in central Kentucky—in general, grasses increase in adaptability as one proceeds northward and eastward in the United States. Not only are the North Atlantic states well adapted to the production of grasses, but they are less adapted to the production of cereal crops. The result is that the proportion of the total farm area in grasses is much higher in these states than elsewhere, except in those Rocky Mountain states where range conditions still exist. It has been fairly well demonstrated that to the cotton states and the sub-humid High Plains area, timothy, blue grass, redtop, and orchard grass are not adapted. Bermuda grass, however, has been introduced in the south, and more recently smooth brome grass has been introduced in the high plains region, and their success leads to the hope that these or yet other grasses may be found which will be adapted to these large areas of the United States.



Percentage of the improved farm land in hay and forage in 1899

35. Yield.—The average yield of hay from the tame grasses in the United States in 1900 was 1.1 tons per acre, and did not vary greatly in different parts of the United States. A yield of 2 tons per acre of well cured hay is usually considered a satisfactory yield, and a yield of 3 tons is considered rather unusual, although a yield of 9 tons per acre has been reported. The Cornell Station produced 47 tons of well cured timothy, red, and alsike clover hay from 12 acres.

The yield of pasture may be stated in the number of animals supported or the returns obtained therefrom. An acre of first-class pasture of Kentucky blue grass may support a 1,000-pound steer and produce some growth; however, one such animal to 2 acres without additional food is perhaps above the average. The Illinois Station suggests, as the result of two years' trials, that while a grain ration to young steers on good pasture may increase the rate of growth in the animals, the gains rarely repay the cost of food and labor; and that it is doubtful whether the maintenance of cattle or an increase in weight could be secured so cheaply as by exclusive pasturage during the best of the grazing season upon good pastures fully but not over stocked. If profit is to be had where grain is fed cattle on pasture, especially if the grain given be unground, it is essential to have pigs follow the cattle.[1] Milch cows on pasture may require additional food throughout the season. The Pennsylvania Station found that where, in the early season, enough stock was put on pasture to keep the grass cropped short, the pasture became insufficient, and beginning with August additional feed was necessary.[2]

36. Time of Harvesting.—The proper time to harvest hay is manifestly when the largest quantity of the best quality can be secured, provided the expense is not thereby increased. The quantity may be sacrificed to improve quality. Quality may be sacrificed to increase the yield or to decrease the expense in harvesting. The expense and risk of securing timothy may be greater if it is cut early, as it requires more handling and longer exposure in curing than if cut late.

If hay is to be marketed, it is important to distinguish between food value and market value. A ton of early cut hay may contain more valuable nutrients than a ton of late cut hay. As a food for milch cows the former would doubtless be better than the latter. Yet the later cut timothy hay may have the higher market value. Growth signifies an increase of weight. A crop of grass increases in weight of dry substance until it is ripe. There may be a greater loss in weight in the matured plant from the loss of seed, in the case of timothy, or in the loss of leaves and finer parts in the case of clover, than if cut earlier. When ripe, the hay is practically straw.

[1] Illinois Sta. Bul. No. 9 (1890), pp. 319-25.

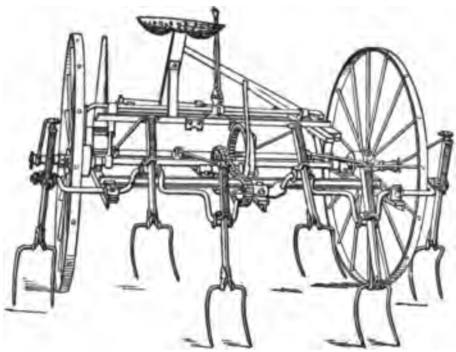
[2] Pennsylvania Sta. Rpt. (1889), pp. 97-101.

A summary of experiments made in this country shows that there is an appreciable increase of yield of the grasses from the period of full bloom until seeds are formed. There is an increase of all the food nutrients, but the increase is most marked in the crude fiber, starch, sugar, and allied substances. With timothy, orchard grass, and meadow fescue, an increase of one-fourth, from the period of full bloom until seeds were formed, has been found. With the clovers, there has been found a decrease in all the nutrients, with the exception of crude fiber, in which there is sometimes an appreciable increase. The loss of the leaves and finer parts in handling while curing is sometimes sufficient to render the clover hay well nigh worthless. There is both a loss of weight and a loss in quality.

A farmer with 150 acres of hay to harvest cannot harvest it all at the theoretically best time. If he sells part of his hay, it is prudent to sell the later cut hay. It has less food value, pound for pound, especially for growing stock and milch cows. In many localities it has a greater market value. In such cases it is usually intended for mature horses, for which purpose it is better suited.

37. Curing Hay.—The aim in curing a fodder crop is to preserve the nutrients with the least loss and in as digestible and palatable a form as may be. It is desired to secure bright, clean hay.

The quality may be reduced by direct washing and dissolving by rains; by bleaching, through the alternate wetting by rains and dews, just as linen is bleached; by becoming musty through heating or fermentation; or by the loss of the more delicate and more valuable parts, as the leaves, when the hay is too thoroughly dried. As before indicated, the latter is an important reason why the quality of clover is improved by curing in cocks. When it is spread thinly on the ground the leaves become dry much sooner than the stems, and every time the clover is handled the leaves are broken and lost. If, on the other hand, the clover is put in cocks before the leaves become dry, the stems and leaves transpire or evaporate the water through the leaves much as they do when the plant is growing. The moisture of the stems passes off through the leaves. This is the sweating of hay. The water collects on the outer surface of the stems and leaves, because it is imprisoned there by the surrounding material.

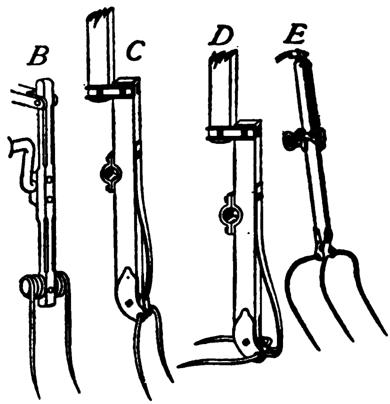


A Hay tedder; fork arms made of boiler tube and coil relief spring

Another reason for placing hay in cocks is to prevent the direct washing and leaching by rains. If an inch of rain falls upon an acre of hay in the swath the hay is likely to be washed by nearly all the rain that falls, or 3,630 cubic feet; but if the hay is in cocks occupying, say one-twentieth the area, then it will be washed with only 182 cubic feet, and as the water will be more or less shed from the cock much of the hay will be untouched.

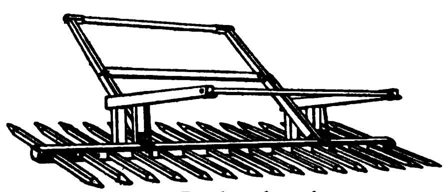
It is not feasible in many places, however, to cure hay in the cock, on account of the extra labor necessary Much hay is now put in the barn or stack on the day after it is cut. Hay rakes, loaders, and horse forks make it possible to do this with but little hand labor, while if put in cock much hand labor is necessary. On the other hand, where only a limited quantity is to be handled, it is often more convenient and more economical to put the hay in cock. The method of handling hay depends much upon circumstances, the main element being the cost of a given method under given conditions. Other things equal, the less the hay is handled the better the quality, as at every movement some of the finer parts may be lost.

III. HAY MAKING MACHINES AND MARKETING



Different styles of hay tedder arms: *B* Coil spring; *C* flat relief spring; *D* flat relief spring sprung; *E* coil relief spring

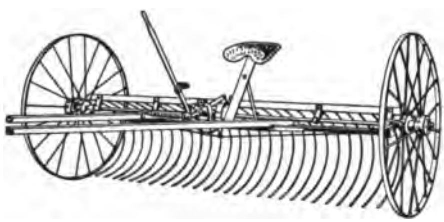
38. Mowing-machines are almost all of one type, in which the cutter bar is placed at one side of the drive wheels (165), although there is a type in which the cutter bar operates between the drive wheels, one horse walking in the standing grass. The essential features of the mowing-machine are: (1) the drive wheel, (2) the pitman, (3) the reciprocating sickle operating through fixed guards, and (4) the divider by which the cut grass is divided from that which is standing. The sickle is made of plain or smooth sections which are kept ground to a sharp cutting edge. (C. A. 163) The ready adjustment of the cutter bar is accomplished by various methods. The length of the cutter bar varies from three feet six inches to seven feet—the most common size for two horses, perhaps, being five to six feet; the larger sizes are used in


A Revolving hay rake

the more level sections. A one-horse mower is made having cutter bar three feet six inches and four feet in length.

39. Hay Rakes.—Several kinds of machines for raking hay into windrows have been invented:

A. The wooden revolving hay rake is drawn by one horse and is made in widths, varying from 9 to 10 feet. The hay is released by the operator raising the handle, which causes the rake to revolve, thus passing over the hay that has been gathered.



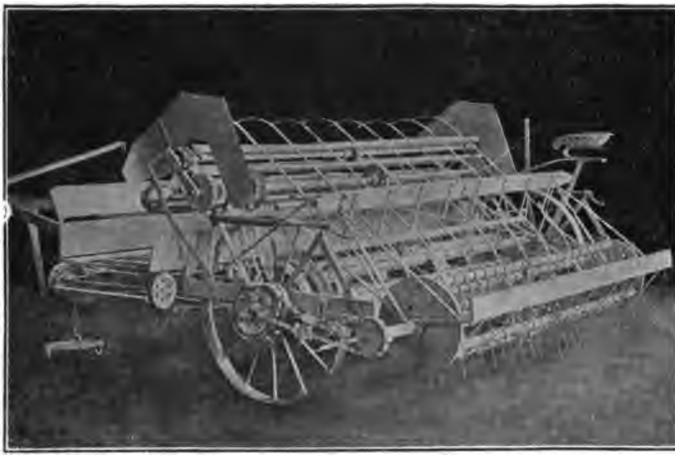
B Sulky hay rake

B. The sulky springtooth hay rake is made in widths varying from 8 to 12 feet, with from 20 to 32 teeth, the wider rakes being for two horses and the narrower rakes for one horse. The hay is released, or "dumped," by pulling back the hand lever, shown in the illustration, or by pressing a foot lever, which by means of a clutch causes the wheel to dump the rake.

C. The side delivery hay rake working somewhat on the principle of a hay tedder, removes the hay to one side of the machine and leaves it in a continuous windrow. This requires nothing of the operator but to drive the team, and allows the hay loader to follow immediately if desired. The standard

C Side delivery hay rake

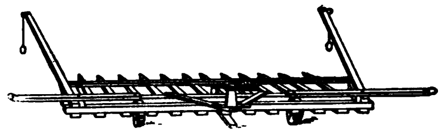
width of this machine is about 8 feet. To get the space covered the width of the windrow must be added. Two horses are used.



D Reversible side delivery hay rake

D. The reversible side delivery hay rake picks the hay up by means of a cylinder on which are mounted gathering fingers. The elevator deposits the hay upon an endless carrier, which may be operated in either direction, thus depositing the hay upon either side of the rake. The rake is eight feet wide and is drawn by two horses.

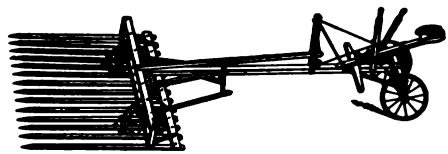
E. The sweep hay rake is used for stacking hay in the field. The hay may be gathered from swath, windrow, or cock when it is drawn directly to the stack. The hay may then be placed upon the stack with the horse hay fork, or more commonly, by means of the hay stacker. (See 42 *E*)



E Sweep hay rake

F. The push power or rear hitch sweep hay rake permits the gathering of the hay close to fences and irrigating ditches, and enables it to pass more readily through gates and over culverts.

G. The windrower is a simple attachment to a mowing-machine, particularly designed for harvesting clover and alfalfa for seed, but may also be employed when these crops are used for hay. (165)



Push power sweep rake

40. Hay Tedders are made with six and eight forks and for one or two horses. The fork arms may be made of wood or of boiler tube. The fork may be two or three-tined, and may have *B* a coil spring, *E* a coil relief spring, or *C, D* a flat relief spring. Care should be taken to use the tedder before the hay becomes too dry, in order to prevent loss of the finer and more valuable parts.

41. Hay Loaders.—In those sections of the country where the climatic conditions or the kind of hay raised make it possible to cure it satisfactorily without placing in cocks, where the fields are fairly level and the hay is not stacked in the field, the hay loader is extensively used. Under these conditions the mowing-machine, the side delivery hay rake, and the hay loader are the three machines which the hay maker uses in the field.

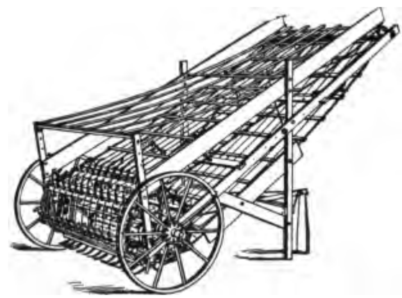
B Hay loader; compare with *A*

Hay loaders are of two general types:

A. In one type the hay is picked up from the swath or windrow by means of a gathering cylinder, from which it is conveyed by means of a carrier to the load.

B. In the other type the rakes engage the hay, moving it forward and upward, where it is engaged by the revolving teeth, which automatically push up and let go as succeeding teeth engage the hay.

Each type has its advantages and disadvantages. The last mentioned type pushes the hay constantly forward; as there is no return carrier which tends to drag the hay backward, it is easier for the loader. On the other hand, the first mentioned type agitates the hay less and hence is less likely to break off the finer and more valuable parts.

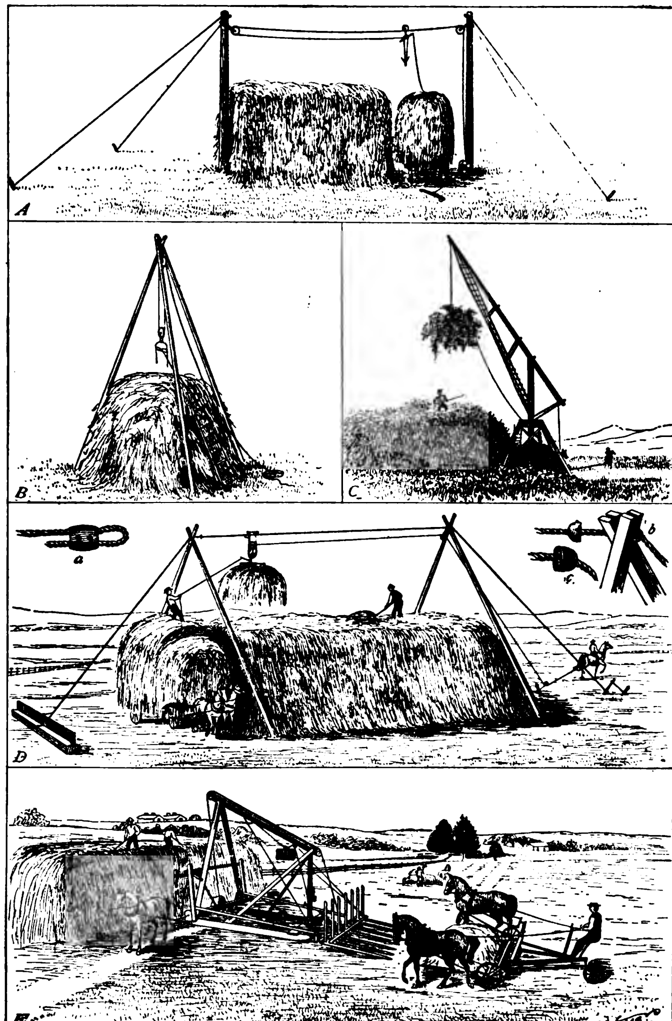


A Hay loader; compare with *B*

42. Stacking.—Where hay is placed in the barn, a wooden or iron track is usually placed in the ridge of the roof on which a hay carrier runs. The hay is thus elevated from the load by horse power to any desired height and dropped at a convenient spot for distribution in the mow.

Different devices are used where it is desired to place the hay in stacks; *A* and *B* show forms that may be used by cutting poles from the woodlot and using the same rope that was employed in putting the hay into the barn, with some additional guy ropes. In *D* a separate wire rope is used, on which runs an ordinary rope hay carrier.

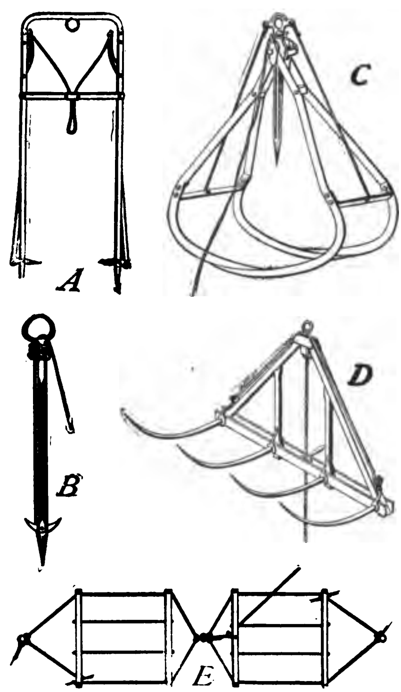
The large swinging hay derricks *C* are used in the alfalfa regions in the West where it is desired to build large stacks. The hay stackers *E* are used when the hay is stacked in the



Devices for stacking hay

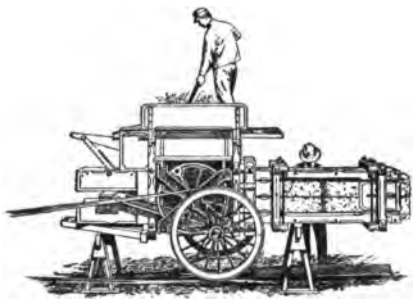
field and where the sweep rake (39 *E*) is used to bring the hay to the stack.

43. Hay Forks.—The general types of forks for unloading hay are shown in this paragraph and do not need further description. The harpoon forks are generally most popular where the hay is long and thus holds together well, as in the case of timothy hay; while for clover and alfalfa the grapple or derrick hay fork is frequently preferred. In some cases rope slings are used. They are made in the form indicated in *E*, or consist of single pairs of ropes with suitable rings at the ends. One pair of ropes is placed lengthwise of the wagon, and a fourth of a load of hay is put on; then another pair of ropes is adjusted and another fourth of the load is added; and so on until the load is completed. The hay is therefore removed in four slingfuls, thus making the unloading quite rapid. The disadvantages are that time must be taken to adjust the ropes, and, in case of an accident, in unloading much hand labor may be required to build the hay over the slings again.



A Double harpoon fork; *B* single harpoon fork; *C* grapple hay fork; *D* derrick hay fork; *E* standard wagon sling.

44. Baling.—An eight-foot cube, or 512 cubic feet of well settled hay in stack or mow, is generally estimated to weigh a ton of 2,000 pounds. Different parts of the stack or mow will vary in density on account of differences in pressure and age, as will stacks or mows of different sizes. There are no data concerning the influence of the character of the hay upon its density, although doubtless redtop hay would have a greater density than timothy hay, and timothy hay a greater density than clover hay.



Belt power hay baling press in operation. May be operated by horse, steam, or gasoline power

When hay is baled to increase the convenience and reduce the cost of transportation it is ordinarily reduced to from one-fourth to one-sixth the bulk occupied in the stack or mow. There is considerable variation in the density obtained by different baling machines, the tendency being to increase the density. Where hay is to be shipped long distances it is sometimes rebaled by hydraulic pressure to a density of 55 cubic feet to the ton.

Hay baling presses differ principally in the size and shape of the bales produced, and the kind, amount, and direction of the power applied. The bale chamber is usually made in three sizes in continuous presses—namely, 14x18, 16x18, and 17x22 inches. The length of the bale may be varied within certain limits by varying the length of bale wire used. The length of bale commonly varies from 38 to 42 inches.

Hay presses may be divided into continuous presses and box presses. In the former the power is applied horizontally, while in the latter it is applied vertically. Continuous presses may be operated by belt or by lever. The horse power lever presses are made either with a reversible lever or with a full circle lever. The box hay presses are operated by horse power or by hand.

The weight of the hay bale is variable, but in general the markets recognize three sizes: large bales weigh from 200 to 250 pounds, medium bales from 120 to 150 pounds, and small bales from 80 to 100 pounds. In some markets the small bales are known as "quarters" or "thirds," and the medium bales as "halves" or "three-quarters," depending somewhat on the weight. Different markets prefer different sizes of bales at different times or for differnt grades. In general, the smaller bales are preferred in the smaller cities or towns and for the lower grades of hay.[1]

45. Marketing.—Hay buyers may sell either on commission or to dealers f. o. b. cars at local station. In selling on commission there are three items of expense—namely, freight, inspection, and commission. As in the case of cereals, there is in the larger cities some agency for the official determina-

[1] The cities of Boston, New York, and Jersey City prefer a bale weighing 200 pounds, style of bale commonly known as the upright bale, using a seven-foot three-inch dimension tie.

The city of Philadelphia prefers a small block bale weighing 90 to 100 pounds, size either 14x18 or 16x18, using an eight-foot three-inch dimension tie for their medium grades of hay; but for No. 1 choice, they prefer the upright bale, same style as New York and Boston.

Baltimore prefers the three-quarter loose pressed bale, weighing 120 to 150 pounds, and the small block bale, weighing from 90 to 100 pounds. The three-quarter size bale should be 17x22, and the small block either 14x18 or 16x18, in each case using the eight-foot three-inch dimension tie.

The Pittsburg market prefers the three-quarter bale. They do not seem to be in the least partial to the small block bale.

Washington and Cincinnati prefer the small block bale, weighing 90 to 100 pounds, using the same length of tie as given above.

Chicago, St. Louis, and Kansas City prefer the quarter bales, weighing from 80 to 90 pounds, size 14x18, using a seven-foot six-inch tie.—Report of Committee on Standard Bales to Nat. Hay Assoc.; in *Flour Trade News*, August, 1906.

tion of the grades of hay, which is binding upon buyer and seller. (C. A. 191)

46. Commercial Grades.—The commercial grades vary somewhat in the different cities, but in general are based upon the same factors—principally the purity, color, and quality of the hay, and the character of the baling. The word "hay" in American markets, when not otherwise qualified, is construed to mean timothy hay, and any other plant, even though it be a cultivated grass, is considered an impurity. The color and quality depend largely on the time of cutting and on the curing, but they also depend somewhat on locality. Some localities produce a timothy which cures a greener color than others. There are, therefore, only certain localities which produce prime hay. Whether these differences are due to climate, soil, cultural methods, or to the strains of seed used has not been determined.

The table following gives the classes and grades of hay recognized by the New York Hay Exchange. The price per ton on a given day is included to show the relative value placed upon the different grades by the trade. These values will vary relatively from time to time, depending on the supply and demand.

Rules for Grading Hay

	Price per ton
PRIME TIMOTHY HAY—Shall be pure timothy of medium growth, bright color, sweet, sound, and well baled	$23.00
No. 1 HAY—Shall be timothy, not more than one-eighth (1/8) mixed with other tame grasses, exclusive of clover, bright color, sweet, sound, and well baled	22.00
No. 2 HAY—Shall include all timothy not good enough for No. 1, fair in color, not more than one-eighth (1/8) other tame grasses exclusive of clover, sound, and well baled	19.50
No. 3 HAY—Shall include all hay not good enough for other grades, not over one-third (1/3) clover, free from wild or bog, sound, and well baled	16.00

SHIPPING HAY—Shall consist of hay not good enough for No. 3, sound, and well baled	$14.00
NO GRADE HAY—Shall include all hay badly cured, stained, threshed, or in any way unsound	Nominal
No. 1 PACKING HAY—Shall consist of all fine grasses, of good color, free from flag or thistles, sound, and well baled . .	11.00
FANCY CLOVER MIXED HAY—Shall be bright, green, sweet clover, and timothy of medium growth, containing not over one-third (1/3) clover, sound, and well baled	18.00
No. 1 CLOVER MIXED HAY—Shall be clover and timothy, medium growth, with at least one-half (½) clover, bright color, sweet, sound, and well baled	17.00
No. 2 CLOVER MIXED HAY—Shall be clover and timothy, with at least one-half (½) clover, fair color, sound, and well baled .	15.00
No. 1 CLOVER HAY—Shall be bright, medium growth, sweet, sound, and well baled	16.00
No. 2 CLOVER HAY—Shall be clover of fair color, sound, and well baled	14.00

47. COLLATERAL READING.—William Jasper Spillman: Farm Grasses of the United States, pp. 14-55. New York: Orange Judd Co., 1905.

Harry Snyder: Soils and Fertilizers (sec. ed.), pp. 225, 226; 241-5. Easton, Pa.: The Chemical Publishing Co., 1905.

Isaac Phillips Roberts: The Fertility of the Land, pp. 207-213. New York. The Macmillan Co., 1897.

W. A. Henry: Feeds and Feeding, pp. 178-185. Madison, Wisconsin: The Author, 1900.

Jared G. Smith: Meadows and Pastures. U. S. Dept. Agr., Farmers' Bul. No. 66 (1899), pp. 7-15.

III

PERENNIAL FOREST GRASSES

I. TIMOTHY

48. Name.—Timothy (*Phleum pratense* L.); synonyms: Herd's grass, meadow cat's tail. The name timothy comes from Timothy Hanson or Hanso, of Maryland, who is said to have introduced the seed from England in 1720 and who is responsible for its distribution through Virginia and Carolina. The name Herd's grass is from John Herd, who is said to have found it growing wild in a swamp in New Hampshire as early as 1700 and began its cultivation, resulting in its distribution through New England and New York. Meadow cat's tail, the oldest name given to the grass, is due to the appearance of the head.

49. Relationships.—Timothy is closely related to meadow foxtail and is the only cultivated grass for which it could with any possibility be mistaken. The latter, however, may be distinguished by its shorter and more ovate head, the bent dorsal awn of the flowering glume, and differences in the shape of the grain and of the outer glumes. There are about ten more or less definitely recognized species of the genus *Phleum*, the most important of which, aside from the species under consideration, is mountain timothy (*Phleum alpinum* L.).

50. Description.—The plant, as compared with other perennial forage grasses, has rather deep roots. Stolons are commonly, although apparently not always, present. Culms vary in height from a few inches to 6 feet, commonly 2 to 4 feet. They are usually rigid and erect, although sometimes decumbent at the base, prostrate, or even kneed. Usually there are two to seven nodes to each culm, each bearing a leaf, although the lower node may not. Usually one, and occasionally more, of the lower internodes is swollen to form one or more corms or tubers. This character which distinguishes it from other forage grasses is most fully developed on dry soils and may, it is said, disappear entirely when the plant is grown in wet places. Occasionally tuberous branches may occur on the upper part of the stem.[1] There is a large proportion of culm to basal leaves, which with its accompanying leaves is easily cured into hay.

Proliferous (left) and normal (right) inflorescence of timothy

The leaf blade varies in thickness and color, common variations being from one-eighth to three-eighth inch in width, and from 3 to 15 or more inches in length. The radicle or basal leaves vary also in erectness, those with long, erect blades being best for hay.

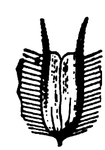
The inflorescence is usually called a spike, although in reality it is a contracted panicle, which form it not infrequently assumes. It usually varies from 2 to 7 inches in length, extremes of two-tenths to 13 inches having been reported; in width, two-tenths to five-tenths of an inch. It also varies in the compactness of the spikelets. Compact spikelets produce harsh, firm, rigid heads, while in some cases the head cannot maintain

[1] Vermont Sta. Bul. No. 94 (1902), p. 144.

itself on account of the loose arrangement of the spikelets The spikelets are one-flowered. The flowering glume is hyaline, toothed, awnless, much shorter than the outer glumes; the palea is hyaline and quite narrow. The outer glumes are truncate, with stiff hairs on the keel which extends into a point or short awn less than half the length of the glume.

A head of timothy in the form of a panicle.

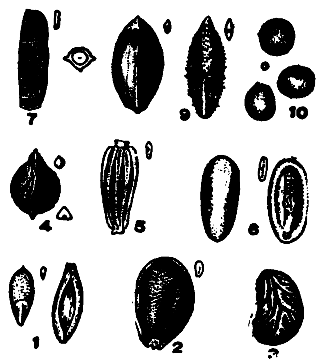
51. Seed.—The naked seed or caryopsis is ovoid, one-fifteenth to one-twelfth of an inch in diameter, usually enclosed in the flowering glume and palea but free from them; hence when closely threshed or re-cleaned, many naked seeds occur. Timothy seed is not ordinarily subject to much adulteration. The most common foreign grass seeds are redtop, fowl meadow, and the foxtails. Fresh, well-ripened seed has a silvery-white appearance, which may, however, be discolored if the seed is wet during the harvest season. Timothy seed may occur on the market in three sizes, as follows: (1) About 600,000 to the pound; (2) 1,200,000 to the pound; and (3) 2,000,000 to the pound.



Spikelet of timothy. Enlarged four times.

The relative value of these grades has not been determined, although the result of two years' trial at the Cornell Station was slightly in favor of the large seed, both when the same weight and when the same number of seeds were sown per acre. At the Utah Station no material difference in yield was found between seeds of high and low specific gravity. The standard of germination is 90 per cent. and the purity should not be less than 98 per cent.

Timothy is cut for seed with the self-binding harvester and placed in shocks without caps. In a few days it is ready for threshing by the same machinery used for small cereals by changing the sieves and adjusting the concaves. The usual yield of seed per acre is from 400 to 500 pounds. The legal weight per bushel is 45 pounds in the states and 48 pounds in Canada.



Timothy seed and its impurities. 1. Timothy (*Phleum pratense*) without and with the glumes; 2. pepper grass (*Lepidium virginicum*), 3. *Potentilla monspeliensis;* 4. sorrel (*Rumex acetosella*); 5. oxeye daisy (*chrysanthemum leucanthemum*); 6. rib grass plantain (*Plantago lanceolata*); 7. Vervain (*Verbena hastata*); 8. witch grass (*Panicum capillare*); 9. crab grass (*Panicum sanguinale*); 10. dodder (*Cuscuta trifolii*)—the small figures natural size.
(After Hicks)

52. Variations.—While three or four varieties or forms of timothy have been recognized by botanists, and while timothy is known to vary widely in yield, duration, time of blooming, and character of growth, evidently both on account of environment and heredity, as yet no varieties have been commercially distributed in America. While the species as a type is perennial, certain individuals are at best only fall annuals, as in the case of winter wheat; while others are biennial, the duration evidently depending on the extent of the vegetative multiplication of the individual seedling. A variation of three weeks has been observed in the time of blooming.[1]

53. Improvement.—Hopkins in 1893 in West Virginia began the selection of timothy and the propagation of the selected strains. These strains are now in the possession of the Division of Agrostology of the United States Department of Agriculture. In 1903 the Cornell Station obtained timothy seed from 231

[1] Samuel Fraser: Thesis: A Study of Timothy, M. S. degree, Cornell University, 1905.

sources, including 21 states, nine European countries, Canada, and Japan. From this seed and its progeny, about 20,000 individual plants have been produced, and from these plants 22 types have been selected for propagation. The observations thus far made indicate that yield and time of blooming are characters which may be propagated by seed alone, and lead to the hope that other characters may be also. For example, it may be that strains of timothy will be developed better

Timothy breeding nursery at Cornell Station

adapted to pasturage than the present type, which, with timothy's present quality of producing abundantly the year after seed is sown, would make them desirable in systems of rotation.

It has not been determined fully whether timothy is close or cross-fertilized. It seems probable from investigations thus far made that it is self-fertilized or fertilized by pollen from the same head, and also cross-fertilized within narrow limits. In all attempts to improve timothy, methods should be based on the assumption that cross-fertilization is possible. It has been shown that a single culm does not ordinarily stay in bloom more than two days; thus a difference of more than two days in time of blooming would prevent cross-fertilization. In some instances, however, a head may stay in bloom for seven days.

54. Adaptation.—Timothy is indigenous throughout the temperate regions, except in Australia. As a cultivated grass, it is especially adapted to the North Atlantic and North Central states east of the Missouri River. Nowhere else in the world is timothy so well and favorably known. It is pre-eminently the hay plant of the grass family in the United States. No other plant of the grass family compares with it in extent of production for hay. It is almost exclusively the hay of commerce in the eastern half of the United States. Redtop, clover, and alfalfa are sold to some extent, but the amount is small compared with timothy.

Timothy is better adapted to clay than to sandy soils, to moist than to dry climates. It is at its best on moist and fertile soils. On soil of light sandy character that had been cropped for three years in potatoes, the Minnesota Station obtained, as an average for three years, .74 ton of timothy hay; on low soil well supplied with moisture the average for two years was 1.76 tons; while on new land, low, and five years from breaking, the yield at the first cutting was 2.17 tons.[1]

It is perfectly hardy in the most northern portions of the United States and throughout Canada, and has been found satisfactory in meadows and in pastures in Alaska. The Rhode Island Station reports that timothy does not thrive on very acid soils until lime, wood ashes, or else very large and continuous applications of stable manure are made.[2]

55. Rotations.—Timothy enters into nearly all rotations in the North Atlantic and North Central states and usually occurs for two or more years. The most common rotation consists of maize, oats, and wheat each one year, followed by timothy and clover for two or more years, the clover disappearing after one or more years. At the North Dakota Station four crops

[1] Minnesota Sta. Bul. No. 81 (1903), p. 197.
[2] Rhode Island Sta. Bul. No. 99 (1904), p. 101.

of wheat after two crops of timothy yielded on an average nearly six bushels of wheat more per acre than wheat grown continuously on adjacent land, giving better results than were obtained by rotating with cultivated crops.[1]

56. Amount of Seed.—When sown alone it is customary to sow 15 pounds or one-third of a bushel per acre; when sown with red clover, 9 pounds or one-fifth of a bushel per acre. The Cornell Station has sown amounts varying from 5 to 35 pounds per acre. The results of two seasons' trial indicate that 15 pounds per acre is a desirable quantity when sown alone. The Utah Station sowed timothy seed at the rate of 8, 16, 24, and 32 quarts per acre. The two extremes gave the smallest yields. The Rhode Island Station recommends for meadows 15 pounds of timothy seed, 7.5 pounds of cleaned fancy redtop, and 7.5 pounds of red clover seed per acre; if clover is omitted, 20 pounds of timothy and 10 pounds of redtop. The Minnesota Station recommends timothy 7, red clover 6, and brome grass 4 pounds for grass to lie two to three years in the rotation in southwestern Minnesota; to lie three to five years, timothy 7, red clover 6, brome grass 10 pounds. For meadows that are to be broken up at the end of the second year, the following mixture has been used to advantage at the Ontario Agricultural College: red clover 6, alsike 3, timothy 4, perennial rye grass 2 pounds. For economic reasons, perennial rye grass may sometimes be omitted from this mixture and, in case the land is to be pastured part of the time, be replaced by orchard grass.[2] When sown with clover, the South Dakota Station recommends timothy 11 and clover 2 pounds, with variations to suit conditions.

57. Seeding.—Timothy may be sown either in the fall or in the spring with any small grain that is sown at the time. A good

[1] North Dakota Sta. Bul. No. 43 (1900), p. 541.

[2] Ontario Agr. Col. & Expt. Farm Rpt. (1895), p. 185.

stand will be obtained oftener, probably, by sowing in the fall, except in the dry prairie states of the Northwest, where spring sowing is best. The seed should be well covered and probably more deeply than is the general practise. Sowing the seed in front of the hoes of the wheat drill brings good average results in some localities, while sowing behind the hoes is preferred in other sections. Timothy may be sown with any small cereal, but probably rye is the best and oats the poorest crop for this purpose. In some localities it is sown alone in the autumn and a crop harvested the following summer. (25)

58. Time of Cutting.—Timothy is what is called a late grass, being ready to cut in July. This is a great advantage for this country, since it can be much more easily cured and with so much less risk of injury to quality than if it were cut in June, both because it cures more quickly and because there is in general a less number of days of rainfall in July than in June.

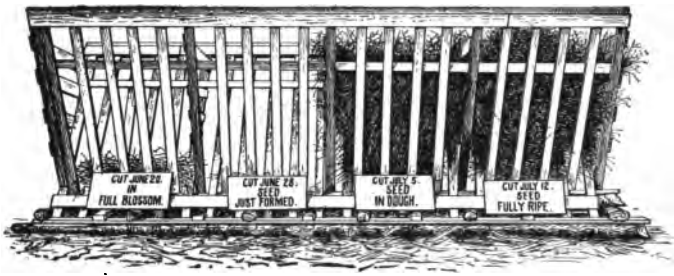
It has been customary to recommend that timothy should be cut in bloom or just past bloom. The following table gives the yield per acre of the dry matter or water-free substance of timothy cut at different dates, as determined by three experiment stations:

Table Showing Influence of Maturity on Yield of Dry Matter

The rate is stated in pounds per acre

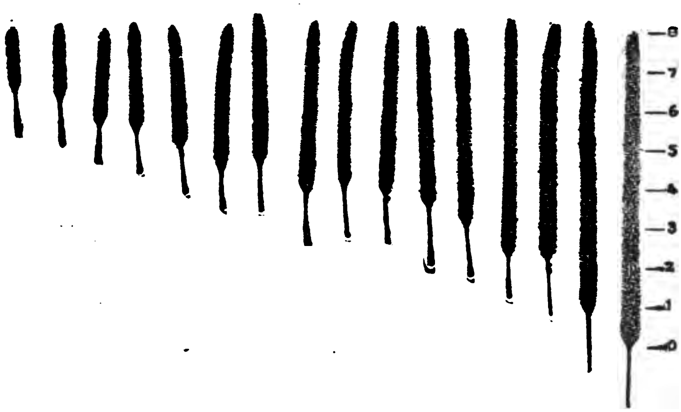
Stage of Maturity	Connecticut	Illinois	Pennsylvania
Well headed out . . .	2,750	....	....
Full bloom	3,300	3,285	2,585
Out of bloom . . .	3,115	3,425	....
Seed in dough . . .	....	4,010	....
Seed nearly ripe . . .	3,615	4,065	3,065

There was not only an increase in the total weight of dry



Palatability of timothy hay. This rack shows way timothy hay was eaten by cattle when harvested at different stages of maturity. Each of the four compartments was filled with equal quantities of hay cut at the periods indicated and cattle allowed to eat at will. (From photo by Missouri Station)

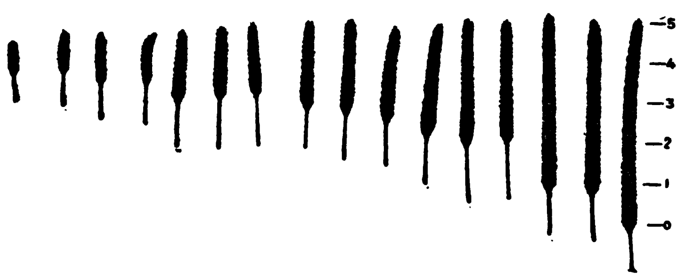
substance in each instance, but there was in general also an increase in each of the food nutrients, although the percentage of nitrogenous matter decreased as the plant became ripe.



Timothy
The percentage of large heads of timothy in field not infested by the timothy joint-worm
Scale of inches at right
(After Webster)

Data with reference to the digestibility of timothy at different stages of maturity are meager, but the indications are that the digestibility does not decrease to any great extent up to the time the seed is in the dough. Practical experience shows that for horses, at least, the palatability is not materially decreased. The indication is, therefore, that the cutting of timothy may be safely postponed until after it is well past bloom. All things considered, probably when the seeds are in the dough would be the best time to mow timothy.

59. Advantages.—The great popularity of timothy as a hay crop is due to the very satisfactory reason that it produces an abundance of hay of good quality over a large territory and on a considerable variety of soils. It is easily and cheaply grown, rarely lodges, cures quickly, and there is little waste in handling. The fact that it can usually be put into the barn or stack soon after it is cut makes it possible to handle it with a minimum amount of labor, and decreases the risk of having the hay spoiled during inclement weather. The stage of



Timothy
The percentage of undersized heads of timothy in field infested by the timothy joint-worm. Scale of inches at right
(After Webster)

maturity may vary considerably without materially influencing its commercial quality and perhaps not greatly its actual feeding value per unit of weight. The haying season may therefore extend over a considerable period of time.

60. Comparison of Timothy and Orchard Grass Seed.—Commercial timothy seed is cheap, clean, and ordinarily germinates well. Timothy produces from 400 to 500 pounds of seed per acre, orchard grass from 200 to 250 pounds of seed per acre. The number of seeds in a pound of timothy is from two to three times that of orchard grass. The germinating power of the latter is rather less. Thus 15 pounds of timothy seed costing 5 cents per pound, or 75 cents per acre, would be as good a seeding as 30 pounds of orchard grass costing 20 cents per pound or $6 per acre. If there were a greater demand for orchard grass seed it would probably become somewhat cheaper than at present, since it is not difficult to raise or to prepare for market; but owing to the above circumstances, it probably always will cost four or five times as much to seed an acre of land to orchard grass as to timothy.

61. Disadvantages.—Ordinarily timothy produces but one crop in a season and does not produce much aftermath. It often grows very little for several weeks after the crop is harvested. In hot, dry seasons this lack of vegetation, especially when mown close to the ground, causes the plant to be injured. It is desirable where such danger exists to mow rather high. Timothy is slow to start in the spring. It does not produce a dense sod. When not grazed closely it becomes coarse and woody and is therefore not as palatable for pasture as some other grasses. Its duration is uncertain, especially where closely pastured. It is also more readily injured by tramping, particularly where the ground is soft, than Kentucky blue grass or redtop.

II. MEADOW FOXTAIL

62. Description.—Meadow foxtail (*Alopecurus pratensis* L.) is closely related to timothy, for which it may be mistaken; although it blooms fully a month earlier, its culms are not so tall, its heads are shorter and more ovoid. (49) Meadow foxtail is distinctly stoloniferous and therefore makes a good sod in its proper habitat. Culms are few, 1 to 3 feet high, sparingly furnished with leaves. The basal leaves are broad, long, thin, and grow rapidly when cut or eaten by live stock. The

Spikelet of meadow foxtail. Enlarged four times.

Meadow foxtail taken at Cornell Station June 15. Spike on left past bloom. One-third natural size

inflorescence is a spike-like panicle, ovoid, 1.5 to 3 or more inches long. Spikelets are one-flowered. The flowering glume usually has a bent dorsal awn; palea is often wanting. Empty glumes are hairy, acute but not awned, and are united below the middle.

63. Seed.—Seed is sparingly produced and therefore expensive. It is generally of poor vitality and hence a good stand is seldom obtained, at least in America. The number of seeds per pound is 1,216,000. All commercial seed is imported.

64. Adaptation and Value.—Lawson says, "Grows naturally on rather superior soils of medium texture, and constitutes the greater portion of many of the richer, natural pastures of Britain. It requires two or three years after sowing to arrive at full maturity and, therefore, it is not suitable for alternate husbandry."[1] Hackel states that it is especially adapted to wet meadows. Meadow foxtail is distinctly a pasture grass, being one of the earliest grasses to start in the spring. On rich soils it may be tried in mixtures for permanent pastures at the rate of 1 pound of seed to the acre.

Meadow foxtail taken at Cornell Station June 15. Plant well past bloom. Highest culm 30 inches; clump 15 inches wide; 21 months old from single seed. One-twelfth natural size.

65. Collateral Reading.—William Jasper Spillman: Farm Grasses of the United States, pp. 75-89. New York: Orange Judd Co., 1905.

F. G. Stebler and C. Schröter: The Best Forage Plants, pp. 52-60. London: David Nutt, 1889.

W. J. Beal: Grasses of North America, Vol. I, pp. 151-3. New York: Henry Holt & Co., 1896.

Thomas Shaw: Grasses and Clovers, Field Roots, Forage and Fodder Plants, pp. 10-19. Minneapolis: Northrup, Braslan, Goodwin Co., 1895.

A. D. Hopkins: Breeding Timothy. In American Breeders' Association, Vol. II. (1906), pp. 95-9.

Thomas A. Williams: Timothy in the Prairie Regions. In U. S. Dept. Agr. Yearbook 1896, pp. 147-154.

Henry Prentiss Armsby and J. August Fries: The Available Energy of Timothy Hay. U. S. Dept. Agr., Bu. An. Ind. Bul. No. 51, 1903.

Willet M. Hays: Plant Breeding. U. S. Dept. Agr., Div. Veg. Phys. and Path. Bul. No. 29 (1901), pp. 61-3.

John W. Gilmore and Charles P. Clark: Second Report on the Influence of Fertilizers on the Yield of Timothy Hay. New York Cornell Station Bul. No. 241, 1906.

[1] The Lawson Seed and Nursery Company: Agrostographia; Treatise on Cultivated Grasses, Sixth ed., p. 23.

H. Garman: On the Adulterants and Wild Seeds Found in Kentucky Samples of Blue Grass, Orchard Grass, Timothy, Red Clover, Mammoth Clover, and Alfalfa Seeds. Kentucky Station Bul. No. 124, 1906.

L. R. Jones: Impurities in Timothy Seed. In Vermont Station Report 1900, pp. 290-6.

J. B. Killebrew: Grasses and Forage Plants. Tennessee Station Bul. Vol. XI (1898), Nos. 2, 3, and 4, pp. 9-14.

IV

PERENNIAL FORAGE GRASSES

I. REDTOP

66. Relationships.—The genus *Agrostis* contains about 100 species distributed over the entire globe, but especially in the North Temperate Zone.[1] There is some dispute as to the proper classification of the cultivated species, perhaps due to the fact that they are only cultivated varieties and vary greatly with soil and climatic conditions. There are three kinds of seed on the American market—namely, (1) redtop, chiefly harvested in southern Illinois, (2) creeping bent, imported from Europe, and (3) Rhode Island bent, produced principally in Rhode Island, although seed of this type is also imported.

As ordinarily sold by seedsmen, Rhode Island bent is *A. canina* L., a small type with a strongly creeping habit, fitting it for lawns and permanent pastures, but making it unsuited for a hay crop. This type may be distinguished from the other cultivated forms by the absence of the palea. The flowering glume is awned, while in the other cultivated forms usually it is not awned. The other two cultivated forms belong to *A. alba* L. and its sub-species *A. alba vulgaris* (With.) Thurb. These two forms differ from each other more in habit of growth than in botanical characters, and even in habit of growth there are so many intermediate forms as to make the distinction arbitrary. *Agrostis alba* is the taller and more robust type with red or purple panicles. *Agrostis alba vulgaris* differs from *Agrostis alba* by its more slender culms, seldom reaching

[1] Hackel: The True Grasses, p. 111.

more than 18 inches in height, finer leaves, shorter and more obtuse ligule, smaller panicle with fewer branches.

In a letter, Mrs. Agnes Chase says: "*Agrostis alba vulgaris* can usually be distinguished from *A. alba* by the habit of the plant, but they are so nearly allied that the spikelets alone are not distinct. When making the drawings for Professor Hitchcock's 'Agrostis' I examined a great amount of material of these two kinds to find if possible some clear distinction in the spikelets of the two, but was unable to find such distinction. The spikelets are the same size, but *alba* usually has a palet two-thirds to three-fourths the length of the flowering glume and *var. vulgaris* has a palet about one-half the length of the flowering glume. *Agrostis alba*, however, so frequently has a shorter palet that this character cannot be relied upon. But in examining a quantity of seed, if I find only shorter palets, I think it safe to assume the seed is that of *var. vulgaris*."

Hitchcock says of *Agrostis alba* L.: "Extensively cultivated as a meadow grass under the name of redtop, and a more stoloniferous form as lawn grass under the name of creeping bent. . . . The stoloniferous form used for lawns has been generally known as *var. stolonifera*, but it is not *A. stolonifera* L. which is *A. verticillata* Vill. . . . The form evidently introduced through a large part of the United States is the large plant which I have referred to *A. alba* L. This has taller stems, wider leaf blades which may droop, larger, more dense panicles, the branches often spikelet-bearing to the base, ligules larger and the stolon-like rhizomes often long and stout."[1]

"When seeding plow-lots for a crop or two of hay, we should feel cheated if a seedsman were to sell us, inadvertently, the smaller, to mix with timothy, instead of the larger variety of *Agrostis*. On the other hand, when tired of plowing a field, and wishing to seed it so it will run from a meadow into a permanent 'butter pasture,' perhaps, or a green home-lot, with a fine, close sward at bottom, we take much pains to get seed of the smaller grass. Sod of the larger one never tempted spade to lift it, but turf of fine *Agrostis* is a beautiful possession."[2]

Mrs. Chase writes: "I have examined packages of seed sold as 'creeping bent.' These are *A. alba*, probably *var. vulgaris*, but in all packages I found some *A. canina* and one package was nearly half composed of that species."

Redtop is botanically more closely related to timothy and meadow fescue than to the *Poas*, the fescues, or orchard grass, in that the spikelet is one-flowered and the florets are hyaline instead of chartaceous.

[1] North American Species of Agrostis. U. S. Dept. Agr., Bu. Pl. Ind. Bul. No. 68, p. 26.

[2] James B. Olcott: Fine versus Coarse Agrostis; in Rpt. Conn. Bd. Agr. and Exp. Sta., 1887, p. 177.

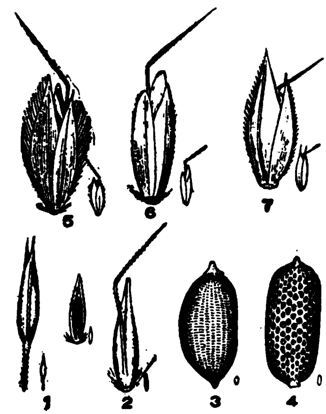
67. Description.—The roots are more shallow than timothy; the plant is strongly stoloniferous, especially upon moist soils, making a firm sod which stands tramping well, and also makes the grass useful for preventing soils from washing. The culms are 1 to 3 feet tall and are frequently decumbent at the base. The nodes which come in contact with the ground root freely.

The inflorescence is an erect, open, much-branched spreading panicle with many one-flowered spikelets, 1.5 to 7 inches in length, with an expanse of the lower branches half such length. The panicle is at first contracted and green in color, but later expands and assumes the characteristic purple color. The flowering glume is hyaline, usually awnless; palea short, often minute or wanting. Empty glumes longer than flowering glume. Redtop has a superficial resemblance to Kentucky blue grass. The general observer may distinguish it from the latter by the purple color of the panicle and the smaller and more numerous spikelets. The fact that the spikelets are one-flowered in redtop and from three to five-flowered in Kentucky blue grass serves to separate them positively.

Redtop taken in central New York State June 28 Just coming into bloom. One-third natural size

Spikelet of redtop. Enlarged four times.

Redtop flowers four to six weeks or even eight weeks later than Kentucky blue grass, and is therefore less likely in the field to be confused with the latter than with fowl meadow grass (*Poa flava* L.), which flowers at the same time as redtop. (71) Redtop seed is sold in the chaff—namely, with its relatively large outer glumes, when a bushel weighs about 12 pounds; or re-cleaned—that is, with the outer glumes removed, when it weighs about 35 pounds to the bushel. A pound of re-cleaned seed is equivalent to four or more pounds in the chaff.



Seeds of Agrostis and Alopecurus with impurities. 1. Redtop (*Agrostis alba*); 2. Rhode Island bent (*A. canina*); 3. slender rush (*Juncus tenuis*); 4. Canadian St. John's-wort (*Hypericum canadense*); 5. meadow foxtail (*Alopecurus pratensis*); 6. slender foxtail (*Al. agrestis*); 7. creeping soft grass (*Holcus mollis*)—the small figures natural size.
(After Hicks)

The grain is 0.04 inch in length enclosed in flowering glume about one-half longer, giving a silvery appearance to the seed. The number of re-cleaned seeds per pound is variously reported: Illinois Station,[1] 4,135,900; North Carolina Station,[2] 6,400,000; Lawson,[3] *A alba* var. *stolonifera*, 8,000,000, *A. vulgaris*, 7,800,000. Redtop seed is not usually adulterated, the most common foreign seed being timothy. Seeds of slender rush (*Juncus tenuis* Willd.) and sorrel (*Rumex acetosella* L.) occasionally occur. The standard of germination is 85 per cent. Commercial seed is not infrequently below this standard. The amount of seed to sow per

[1] Illinois Sta. Bul. No. 3 (1888), p. 33.

[2] North Carolina Sta. Bul. No. 73 (1890).

[3] Agrostographia, Sixth ed., p. 40.

acre is variously estimated from 6 to 30 pounds—perhaps 12 to 18 pounds of re-cleaned seed being most commonly recommended when sown alone, and 6 to 10 pounds when sown with timothy or timothy and red clover. Time and manner of seeding are similar to that of timothy, except greater care is required not to cover seed too deeply.

68. Adaptation.—Redtop will probably thrive under a wider range of soil and climate than any other cultivated grass. Being less esteemed either for hay or pasture, it is cultivated only where other grasses are less successful. As a hay crop, redtop is next to timothy in importance among the grasses in this country. It often, perhaps usually, forms a large part of the herbage of permanent meadows. It is adapted to low, moist lands, and is usually grown on the poorer lands of this sort. It is useful for improving impoverished clay soils on account of the organic matter furnished by its numerous roots, its mass of underground and above ground stems, and its thick, tough sod. It may, therefore, be wisely added to the grass mixture in a rotation on such soils. The Rhode Island Station has shown that it is able to live in very acid soils where timothy, red clover or Kentucky blue grass will not thrive, which may account for its common occurrence in the New England states. Where lands are too poor, too moist, or too acid to grow timothy, redtop may be tried. By the skilful use of this grass in a rotation, lands may be improved and made to grow more desirable grasses as well as to give greater yields of other crops.

69. Value.—Redtop produces a fairly good quantity of hay, it being recognized as being heavy for its bulk. Its feeding value as hay is not considered equal to timothy and buyers are not favorably disposed toward it. In some places where it grows readily farmers take the precaution to keep it out of their timothy meadows, because even a little of it reduces the market value of the hay. The Rhode Island Station found when grown under the same conditions that redtop was richer in nitrogen than timothy, but that a greater percentage of the nitrogen had been changed to albuminoids in the case of timothy.[1]

Redtop makes a sod more quickly than Kentucky blue grass, and on suitable soils produces an abundance of pasturage. It is one of the most permanent of the cultivated grasses. It is, however, distinctly the least palatable of the commonly cultivated grasses—at least so far as cattle are concerned.

II. KENTUCKY BLUE GRASS

70. Name.—Kentucky blue grass (*Poa pratensis* L.). Synonyms: blue grass, June grass, green grass, spear grass, smooth-stalked meadow grass. In some localities the grass is known only as June grass and by many is erroneously believed to be distinct from Kentucky blue grass. In other localities wire grass or Canada blue grass (*Poa compressa* L.) is known as blue grass, while *Poa pratensis* is called green grass.

Kentucky blue grass on the right in full bloom; Canada blue grass on the left not yet in bloom. Taken at Cornell Station June 15. One-third natural size

[1] Rhode Island Sta. Bul. No. 90 (1903), p. 73.

71. Relationships.—The *Poas* are botanically more closely related to the fescues, orchard grass, and brome grass than to timothy and redtop, in that in the former the spikelets are all two or more flowered instead of one-flowered and the flowering glume is chartaceous instead of hyaline. There are about 100 species of this genus distributed throughout all temperate and cold countries and in the high mountains of the tropics. The seeds of a number are commercially distributed, of which may be mentioned: Canada blue grass or wire grass, characterized by its blue color, flat, shorter culms (larger diameter twice the shorter), large spikelets with three to nine flowers and spreading decumbent habit; rough stalked meadow grass (*Poa trivialis* L.), characterized by its aerial runners, rough leaf sheaths, and long ligules; wood meadow grass (*Poa nemoralis* L.); and fowl meadow grass (*Poa flava* L.).

Canada blue grass is, in most parts of the United States, considered a weed, and its occurrence in a field is usually esteemed not only as an indication of decreased value in the pasture, but also an indication of a poor soil. Several authorities recommend it for dry soils. Zavitz, of Ontario, Canada, and Jones, of Vermont, recommend it as superior in feeding value for pasture to Kentucky blue grass; while Spillman states that in eastern Ontario and western New York it is sometimes cut for hay and that although the yield is small, the hay is highly prized, being preferred by horsemen to timothy.[1]

On Dunkirk stony clay in western New York, where land had been in wheat for years until it became very poor, it was observed by Fraser that after ten years the land carried a large proportion of Canada blue grass; that in older grass land Kentucky blue grass predominated, while in still older grass land meadow fescue began to appear. These grasses evidently represent a gradual improvement of the land through years of pasturing, as well as the relative adaptability of the grasses

[1] Farm Grasses of the United States, p. 102.

in question. Cattle are said to be fattened for export on these Canada blue grass pastures at the rate of one steer to 3.5 acres.

Of wood meadow grass, Lawson says: "There is no grass better adapted for pleasure grounds, particularly under trees, as it will not only grow in such places, but forms a fine sward where few other fine grasses can exist." Fowl meadow grass blooms about the same time as redtop, which together with its purplish inflorescence has given it the name of false redtop. Spikelets are two to four-flowered, which serve to distinguish from redtop whose spikelets are one-flowered. The time of blooming and the smaller and less numerous spikelets with purplish tinge serve to distinguish it from Kentucky blue grass. The Vermont Station says: "It (fowl meadow grass) is one of the most valuable of our native grasses, being especially adapted to wet, overflowed intervale land where the usual hay grasses and clovers are liable to be killed by standing water. Redtop and alsike clover are capable of enduring a wetter soil than timothy and red clover, but fowl meadow will thrive best in soil where even redtop and alsike soon kill out. There are many acres in Vermont now occupied by sedges and rushes where fowl meadow grass would grow well if introduced. Seedsmen do not carry good seed of this grass, but it may easily be harvested from the native grass in almost any town in Vermont, providing one knows the grass when he sees it."[1] This station further suggests that, if land is liable to have water standing on it long in the spring, the following mixture of seeds be sown: timothy 6; redtop 6; alsike clover 6 pounds; and fowl meadow grass 0.5 to 1 bushel.

72. Description.—Kentucky blue grass has a strongly stoloniferous habit, making an even although less strong sod than redtop. The rhizomes are not easily eradicated, making it a grass of good duration. Its roots do not penetrate deeply.

[1] Vermont Sta. Bul. No. 94, p. 151.

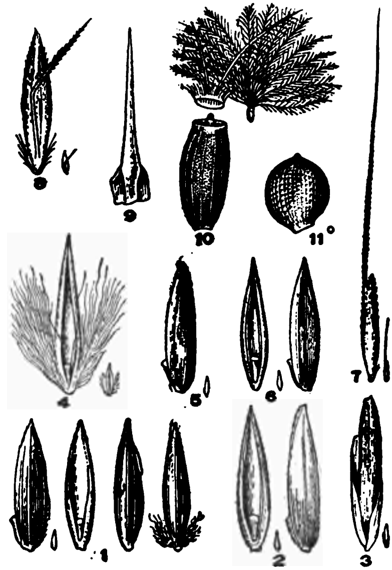
Culms are round, erect, 1 to 2 feet tall. Leaf sheath is smooth; leaf blade narrow, less than one-fourth inch; culm leaves 2 to 6 inches long; basal leaves 1 to 2 feet and in protected places 5.5 feet have been reported. Blade is keeled with boat-shaped tip, the two halves closing when dry.

The inflorescence is an open, spreading, pyramidal panicle 2 to 8 inches long, less branched, and carrying fewer spikelets than redtop. Spikelets are three to five-flowered. The outer glumes are shorter than the nearest flowering glume. The flowering glume in all the *Poas* is keeled, by which they may be distinguished from the *Festucas* in which the flowering glume is rounded on the back. The flowering glume is awnless, but the base and margin and the rachilla are covered with tangled or webby hairs which are removed when seed are cleaned for market. This makes Kentucky blue grass seed more difficult to clean than Canada blue grass seed.

Spikelet of Kentucky blue grass. Enlarged four times.

73. Seed.—The grain or caryopsis is enclosed in its chartaceous flowering glume and palea. The seed—namely, the flowering glume—is shorter than that of meadow fescue or perennial rye grass or orchard grass. It can further be distinguished from orchard grass by the twisted point and the strong spines along the keel of the latter. Kentucky blue grass seed is sometimes adulterated with Canada blue grass seed. The former has a rather more pointed flowering glume which is five-nerved, while the latter has only a keel and marginal nerves. Kentucky blue grass seed (flowering glume) may measure from 0.10 to 0.15; Canada blue grass seed from 0.08 to 0.09 inch in length. Canada blue grass seed has a brighter and cleaner appearance than Kentucky blue grass seed. In mass Kentucky blue grass seed is a deeper brown color. Because of variations these distinctions will not, however, always hold.

Kentucky blue grass is comparatively free from weed seeds, although slender rush, shepherd's purse, chickweed, pepper grass, sorrel, and some other seeds may occur. Kentucky blue grass flowers in May and June, ripening its seed in the latter month. The tendency is to strip the seed while still green, because it is easier both to strip and to clean when harvested green, and because it shatters easily when ripe. This tends to reduce the germinating power, both because seed is unripe and because when harvested unripe it is more likely to ferment during the curing process. The author tested 17 commercial samples in 1891 whose germinating power in soil in the open air ranged from 7.7 to 35.2 per cent., while when ripened seed was gathered and carefully dried 80.1 per cent. germinated.[1] The standard of germination is now placed at 50 per cent., although it is not unusual for only 10 per cent. to germinate. It is necessary in such cases to buy 10 bushels of seed in order to get 1 bushel of live seed.



Seeds of Poas with impurities. 1. Kentucky blue grass (*Poa pratensis*) rubbed and unrubbed; 2. wood meadow grass (*Poa nemoralis*); 3. ergot; 4. Texas blue grass (*Poa arachnifera*); 5. Canada blue grass (*Poa compressa*); 6. rough-stalked meadow grass (*Poa trivialis*); 7. silky bent grass (*Apera spica-venti*); 8. wood hair grass (*Deschampsia flexuosa*); 9. spine of Canada thistle (much enlarged); 10. Canada thistle (*Carduus arvensis*); 11. stink grass, coryopsis (*Eragrostis major*)—the small figures natural size.

(After Hicks)

[1] Illinois Sta. Bul. No. 15 (1891), p. 481.

The legal weight per bushel in most states is 14 pounds, but a well cleaned sample will weigh from 24 to 28 pounds. The Illinois Station reports 2,185,000 seeds; Lawson, 3,888,000 seeds per pound.

74. Seeding.—It is customary to recommend 40 pounds of commercial seed per acre when sown alone for the purpose of securing a good stand of grass as rapidly as may be—as, for example, in the case of lawns. This is at the rate of 2,000 seeds per square foot. It is probable that if 80 per cent. of the seed were viable half this amount would be sufficient. On the other hand, one of the important reasons for failure in practise to secure good lawns is due to using an insufficient amount of viable seeds.

On account of the expense of the seed and the slow development of Kentucky blue grass, it is seldom sown alone for pasture. It is usually sown with a mixture of other grasses and clovers with the expectation that as the Kentucky blue grass develops most of these will disappear. What this mixture should be will depend on soil and climate, and to some extent whether it is to be mown for a year or two or pastured from the beginning. For the North Atlantic and North Central states the following mixture may be taken as a basis to be modified to suit varying conditions; timothy 15; Kentucky blue grass 10; meadow fescue 2; red clover 8 or alsike clover 6, or both in half these amounts; and white clover 2 pounds. Such a mixture will cost from $3 to $4 per acre.

The grass seeds of this mixture may be sown in September and the clover seeds as early as may be in the spring, or the whole mixture may be sown in the spring after the land has been well prepared. If a sod at the earliest possible moment is desired, the mixture should be sown without grain crop. If immediate pasture is wanted, rye may be sown at the rate of one bushel per acre in September with the grass seeds. In general, the best financial returns will be obtained by seeding the grass with wheat or rye in the fall and subsequently harvesting for grain. It has been shown that Kentucky blue grass seeds germinate better if the temperature during a portion of each 24 hours drops as low as 40° F. For this reason, probably fall seeding is especially desirable. The author has had several years' experience in seeding large lawn areas. The best results he ever obtained were in seeding heavily with Kentucky blue grass about November first on the fortieth parallel. For lawn purposes at least 40 pounds of 50 per cent. viable seed of Kentucky blue grass should be used alone or with white clover, and without nurse crop, if the best lawn in the shortest space of time is desired. If greater economy of seeding is required, a mixture of 20 pounds of Kentucky blue grass seed and 10 pounds of timothy may be used.

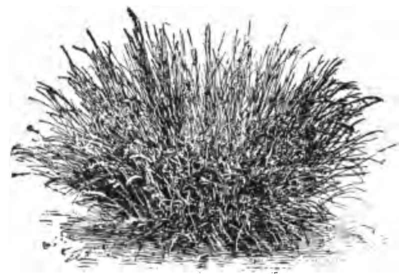
75. Adaptation.—Kentucky blue grass is probably an introduced species. It pretty certainly was introduced into the North Central states by the pioneers, where at the time of its introduction it was looked upon as a dangerous weed. As a cultivated grass, it occupies about the same range in the United States as timothy and red clover. Within this area the relative importance and adaptability of these species vary somewhat. Speaking generally, Kentucky blue grass reaches its best development on fairly well-drained soils between the Allegheny Mountains and the Mississippi River. It does not make good pastures in the non-glaciated region except on limestone soils, such as Hagerstown loam, which constitutes the blue grass region of Kentucky, from which the grass takes its name. In common with other grasses, Kentucky blue grass succeeds better on clay than on sandy soils and in moist rather than dry climates. It will not do its best, however, on heavy, undrained clays where timothy thrives. For its best development the soil should be fertile. Its shallow roots cause it to be easily affected by drought, and in the southern border of its range shade is helpful. Indeed it is distinctly adapted to open woodlands.

76. Advantages.—Kentucky blue grass makes a compact sod which stands a large amount of tramping and very close grazing without injury. On lawns—for which it is unexcelled—the frequent and close cutting apparently improves it. Its leaves are fine, succulent, palatable, and nutritious. It is one of the earliest grasses to start in the spring and one of the latest to grow in the fall. In the more temperate climates it makes excellent winter pasture by keeping live stock off it for a while in the fall. When thus dried standing it is a formidable rival in nutritive qualities of the grasses of the sub-humid regions. As a pasture, it exceeds in palatability with cattle, at least, red-top, orchard grass, and timothy, and equals meadow fescue; it is probably exceeded by smooth brome grass.

Kentucky blue grass taken at Cornell Station June 14. Plant grown from a single seed is 21 months old. Has gone out of bloom. Highest culms 30 inches; clump 30 inches wide. Compare with Canada blue grass.

77. Disadvantages.—The quantity of hay produced is small and, contrary to the usual opinion, the author has found its hay less palatable for cattle and horses than timothy or clover hay. Under ordinary circumstances it is wiser to pasture off mature Kentucky blue grass than to make it into hay.

After seeding, it is a long time in taking possession of the soil—usually three years before anything like a good sod is formed—and it may continue to improve for 10 or 15 years. This is in part due to the very poor germinative power of commercial seed. After plants are somewhat established they spread quite rapidly by means of the underground rootstocks. It often takes possession of the soil when the land is put in pasture. Probably few of the blue grass pastures have been artificially seeded.



Canada blue grass taken at Cornell Station June 14. Plant grown from single seed is 21 months old. Has not yet come into bloom. Longest culms are 18 inches long; clump 3 feet wide. Compare with Kentucky blue grass.

The greatest fault of Kentucky blue grass is its failure to supply good pasture during July and August. During hot, dry periods the growth almost if not entirely ceases. Where spring and fall are short, the amount of pasture may be limited.

78. Harvesting Seed.—Kentucky blue grass seed is mostly secured in Kentucky within a radius of 25 miles from the center of a triangle formed by lines connecting the cities of Lexington, Paris, and Winchester.[1] The seed is obtained by stripping the heads—there being both hand and horse machines for this purpose, the latter now being largely used. The rough seed thus obtained is dried in the house or in the field in windows 3 or 4 feet deep. During this curing process, which takes eight to ten days, the seed must be kept constantly stirred to prevent over-heating. Stripping begins as soon as panicles turn yellow, which in Kentucky is usually from June 7 to June 15. The rough seed is subsequently purified or cleaned at factories with several different machines specially designed for this purpose. The yield of seed will depend on the thoroughness with which it is purified. Of seed weighing 14 pounds to the bushel the yield will run from 100 to 200 pounds per acre; but if seed is

[1] U. S. Dept. Agr., Bu. Pl. Ind. Bul. No. 19.

purified until it weighs 24 to 28 pounds per bushel, 50 to 100 pounds of seed would be considered a good yield.

Canada blue grass seed comes mainly from Ontario, Canada. It is harvested there about August 1. It is cut with an ordinary mowing-machine when the dew is on, cured in cocks for about one week, and then threshed. Five hundred pounds of seed per acre is considered a good yield.

79. Collateral Reading.—F. G. Stebler and C. Schröter: The Best Forage Plants, pp. 65-8; 72-83. London: David Nutt, 1889.

William Jasper Spillman: Farm Grasses of the United States, pp. 90-102; 146-154. New York: Orange Judd Co., 1905.

W. J. Beal: Grasses of North America, Vol. I, pp. 143-151. New York: Henry Holt & Co., 1896.

Thomas Shaw: Grasses and Clovers, Field Roots, Forage and Fodder Plants, pp. 12, 13, and 20. Minneapolis: Northrup, Braslan, Goodwin Co., 1895.

E. Brown and F. H. Hillman: The Seeds of the Blue Grasses. U. S. Dept. Agr., Bu. Pl. Ind. Bul. No. 84, 1906.

J. B. Killebrew: Grasses and Forage Plants. Tennessee Station Bul. Vol. XI (1898), Nos. 2, 3, and 4, pp. 14-17; 53-9.

L. R. Jones: Vermont Grasses and Clovers, Vermont Station Bul. No. 94, 1902.

V

PERENNIAL FORAGE GRASSES

I. ORCHARD GRASS

80. Name.—Orchard grass; cocksfoot (*Dactylis glomerata* L.). Because of its occurrence in shady places, this plant is in America called orchard grass. In England and in New Zealand it is universally known as cocksfoot, because of a fancied resemblance of its panicle to a cock's foot. Although very different in its habit of growth, it is botanically somewhat closely related to the *Poas* and the *Festucas*. The two following grasses cultivated only experimentally belong to the same genus. Tussock grass (*D. caespitosa* Forst.) is indigenous to the Falkland Islands, and is characterized by its large cushions of grass. It has been tried upon the seacoast of Great Britain without success. Russian cocksfoot (*D. altaica* Besser) is distinguished from common orchard grass mainly by its longer culms.

81. Description.—Orchard grass is moderately deep rooted, the roots extending two or more feet into the soil. The Arkansas Station found in northwestern Arkansas, where orchard grass thrives better than timothy, that while all the timothy roots were within 12 inches of the surface 50 per cent. of orchard grass roots were below that depth and 10 per cent. were below 20 inches in depth.[1] The plant grows in a compact raised tuft and is not creeping. The culms are 18 inches to 3 feet tall, and are not abundantly supplied with leaves. The leaf blades are long, sometimes two feet, broad, thick, and strongly keeled.

[1] Arkansas Sta. Bul. No. 29 (1894).

The leaf sheaths are normally entire, but on the culm leaves the sheath becomes partly split by the expansion of the culms. The ligule is long and more or less torn at the apex. The leaves are folded in the bud, *conduplicate,* the young shoots thus appearing laterally compressed.

Orchard grass taken at Cornell Station June 15
Panicle in bloom. One-half natural size

Orchard grass flowers in June after Kentucky blue grass, about the same time as red clover, thus before timothy; at the Illinois Station three to five weeks earlier. The inflorescence is a one-sided panicle, the nearly sessile spikelets being arranged in dense clusters. Spikelets are three to four-flowered. The outer glumes are slightly shorter than the lower flowering glume. When ripe the outer glumes do not detach, but the flowering glume enclosing the grain readily falls away.

82. **Seed.**—In the commercial seed the grain is enclosed in the florets. Not infrequently the seeds remain in pairs. The flowering glume is pointed, the sharp, fringed keel extending into a short awn with a slight twist that helps to identify the

seed. The seed (flowering glume including awn) is about one-third of an inch and without awn one-sixth to one-fourth of an inch long, and the grain is one-tenth inch long. The embryo is very minute.

Spikelet of orchard grass. Enlarged four times.

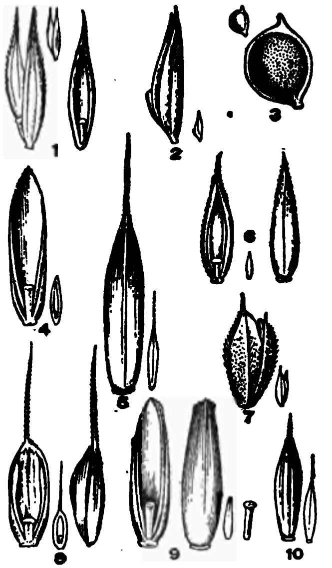
Seeds of meadow fescue and the rye grasses not infrequently occur in orchard grass seed. These seeds in American grown orchard grass seed may be considered adulterations, since meadow fescue and the rye grasses are not usually found growing in the seed-producing section of this country. Meadow fescue, however, is a common impurity in European fields, and velvet grass in New Zealand fields, from which large quantities of orchard grass seed are imported to America. The weeds, which are troublesome in orchard grass fields in the seed-producing section, are whitetop (*Erigeron annuus* (L.) Pers.), red sorrel (*Rumex acetosella* L.), oxeye daisy (*Chrysanthemum leucanthemum* L.), milfoil (*Achillea millefolium* L.), and the plantains (*Plantago lanceolata* L. and *P. aristata* Michx.).[1] Seed growers pay special attention to prevent these weeds from seeding, a common and effective method being to pasture with sheep in the spring until the early part of May or in some instances until seed is ready to harvest, and again after seed is harvested. This practise not only reduces the weeds, but appears to improve the yield of seed as well as furnishing an additional source of profit.

As just indicated, it is possible to furnish orchard grass seed with 100 per cent. purity, and less than 98 per cent. should not be accepted. The number of seeds per pound may vary from 400,000 to 480,000. The legal weight per bushel is usually 14 pounds, but the best well-cleaned seed may weigh 22 pounds to the bushel. The standard of germination should be not less

[1] U. S. Dept. Agr., Bu. Pl. Ind. Bul. No. 100, pt. VI, p. 13.

than 90 per cent., although samples containing 75 to 80 per cent. of living seeds are generally accepted as good.

While it is easily harvested and produces from 150 to 250 pounds per acre under American conditions, the cost of seeding is rather high, both because of the price of the seed per pound and because of the quantity required. When sown alone, 35 pounds of seed per acre are generally recommended when intended for hay and 15 pounds when intended for seed. At the Illinois Station[1] sowing less than 35 pounds reduced the yield of hay. In pasture mixtures 5 to 10 pounds may be sown.



Seed of orchard grass and its impurities. 1. Orchard grass (*Dactylis glomerata*), two seeds cohering, outer face, and single seed, inner face; 2. blue pearl grass (*Molinia coerulea*); 3. tall buttercup (*Ranunculus acris*); 4. English rye grass (*Lolium perenne*); 5. Italian rye grass (*L. italicum*); 6. crested dog's-tail (*Cynosurus cristatus*); 7. velvet grass (*Holcus lanatus*); 8. bearded darnel (*Lolium temulentum*); 9. meadow fescue (*Festuca pratensis*); 10. soft chess (*Bromus hordeaceus*)—the small figures natural size.

(After Hicks)

83. Distribution.—It is native throughout Europe, in temperate Asia, and in North Africa. It is naturalized in North America, where it is said to have been first cultivated. It is sparingly cultivated over a wide area of the United States. Spillman has shown that it is relatively most extensively cultivated in Virginia, North Carolina, Tennessee, and Kentucky—namely, along the southern border of the timothy region.[2] This

[1] Illinois Sta Bul. No. 15 (1891), p. 483.

[2] Farm Grasses of the United States.

may be due to its better adaptation to the soil and climate of that region or it may be due to the fact that timothy thrives less well there. The Arkansas Station recommends orchard grass as the best grass for that state for permanent meadows and pastures. Orchard grass thrives especially well along the Pacific coast west of the Cascade Mountains.

84. Adaptation.—Orchard grass, while perfectly hardy to winter cold, is recognized to be easily injured by late spring frosts. This may account for its more extended cultivation in the region mentioned. Orchard grass is also recognized as enduring shade well; in fact, in shady places it will persist for years and yield abundantly. This has been accounted for by its thick broad leaves. It may also be that the shade prevents injury by late frosts. Orchard grass is not like redtop to be recommended for poor or wet soils, but requires a fairly fertile well drained soil. While a generous supply of moisture is more necessary for its best development than with timothy, it stands periodic droughts much better. The duration of orchard grass is perhaps superior to timothy. Where closely pastured it is said to last three to five years, when it will be generally superseded by the finer grasses.

85. Value.—Orchard grass is a much praised but little cultivated grass in America. It has been cultivated in this country at least since 1764, when it was brought into notice in England by its re-introduction from America. While it has been cultivated more or less since that time, orchard grass hay is not known commercially, and it is known to comparatively few farmers. The fact, however, that it has zealous advocates may indicate that there are special conditions of soil and climate over limited areas in which it produces favorable results.

Orchard grass produces an abundance of leaves early in the season, being one of the earliest grasses to start in the spring. It throws up seed culms nearly as high as those of timothy, but they are produced rather sparingly, especially the first few years after being sown. The result is a comparatively light yield. At the Illinois Station, on rich black prairie soil orchard grass, 35 pounds of seeds per acre, gave during two years an average yield of 1.4 tons of field cured hay; timothy, 15 pounds of seed per acre, 2.2 tons; orchard grass, 17.5 pounds and red clover, 6 pounds, 2.2 tons; timothy, 9 pounds and red clover, 6 pounds, 2.6 tons of field cured hay per acre.[1]

Orchard grass taken at Cornell Station June 14. Plant grown from a single seed is 21 months old. Was in full bloom when picture was taken. Highest culms 44 inches; clump 33 inches wide.

The average of American analyses shows orchard grass to contain a larger percentage of protein and crude fiber than timothy or any other commonly cultivated grass. The hay has the reputation of being less readily eaten by live stock, although it is claimed that this may be remedied by cutting the grass earlier. At the Cornell Station, as pasture it was not as readily eaten by cattle as smooth brome grass, Kentucky blue grass,

[1] Illinois Sta. Bul. No. 15 (1891), p. 486.

or meadow fescue; it was about as readily eaten as timothy and much more readily eaten than redtop.

86. Mixtures.—Because of the habit of orchard grass to grow in tussocks it is generally considered best not to sow orchard grass alone. European authorities recommend that not to exceed 15 per cent. of the herbage shall be orchard grass and that it be not all added at once. Because it ripens at the same time as red clover, they make suitable plants to sow together. At the Illinois Station, however, it was found that red clover developed much more fully when sown with 9 pounds of timothy than when sown with 17.5 pounds of orchard grass. The abundance of basal leaves seemed to have a repressive influence both on red clover and on alsike clover. It has also been recommended for seeding with alfalfa. It is said to help the curing of the first cutting with which it matures, and if pastured to prevent bloating. Those who have tried seeding with alfalfa in the North Atlantic states have not usually continued the practise. According to Spillman, however, this method is highly satisfactory in the Rocky Mountain states. Orchard grass does not, like smooth brome grass, have a tendency to spread and choke out the alfalfa.

87. Cultural Methods.—The time and manner of seeding are similar to that of timothy. If sown with timothy and occupying not more than 20 per cent. of the mixture by weight, it may be sown in the grass seeder, but if sown alone it is best to sow by hand. It is especially desirable to harrow orchard grass meadows in the spring and subsequently roll. A top dressing of manure in the early spring materially increases the yield and improves the quality of the seed.

88. Time of Harvesting.—Orchard grass readily becomes unpalatable and needs perhaps more than any other grass to be harvested without delay when the proper time arrives. In

Switzerland, where orchard grass forms a considerable part of the hay, there is a saying that the time to make hay is when the cocksfoot is in flower. At the Illinois Station there was an increase of 22 per cent. in the weight of water-free substance from full bloom until seed were in the milk, which was a period of eight days. During this period the percentage of ash and nitrogen-free extract increased; the other nutrients decreased.[1] In favorable seasons two crops of hay may be harvested, one in June and the other in August.

89. Harvesting Seed.—American grown seed is chiefly produced in Indiana and Kentucky, near Louisville. Orchard grass is ready to cut for seed when the heads become straw-colored and a slight pressure causes the seed to shatter. In Kentucky this is usually about June 20. Care must be exercised to cut promptly; otherwise seed will shatter badly. For harvesting, the self-binder is used, making rather smaller bundles than for wheat. Three or four bundles are set up together and the tops tied together with two bands about 6 inches apart. The bands are made from straws drawn from the bundles. In 15 to 20 days after it is cut, it may be threshed with a grain thresher provided with screens made specially for orchard grass seed.

II. MEADOW FESCUE

90. Relationships.—The name English blue grass sometimes given to this grass (*Festuca elatior* L. var. *pratensis* Gray) is unfortunate because the name is applied to wire grass or Canada blue grass (*Poa compressa* L.). Closely related to meadow fescue is tall meadow fescue or tall fescue (*F. elatior* L.). Lawson states that this species may be easily distinguished from the former by being much larger (nearly double) in all its parts, which observations at the Cornell Station seem to confirm. Other American observers report it from 2 to 6

[1] Illinois Sta. Bul. No. 5 (1889), p. 147.

inches taller, but otherwise practically identical. The seed of the tall meadow fescue is two to three times as expensive as the smaller type.

Taller fescue taken at Cornell Station June 22. Plant passing out of bloom. Highest culms 51 inches; clump 36 inches wide; 21 months old from single seed. Note the spreading character of basal leaves compared with smooth brome grass.

There are more kinds of seed of the genus *Festuca* carried by seedsmen than of any other genus of grasses. Among these may be mentioned three closely related species or varieties—namely, sheep's fescue (*F. ovina* L.), hard fescue (*F. durius-*

cula L.), and slender fescue (*F. octoflora* Walt.). All have rather fine leaves with a dwarf habit of growth and are adapted to high inferior sandy and gravelly dry soils. Slender fescue has the shortest culms, but is characterized by its long slender leaves, which are of a light, livid green color. In Great Britain, although the yield is small, sheep's fescue is highly prized as a pasture as well as for its indication of a dry soil adapted to sheep. This and other species of Festuca form a part of the sheep ranges of western United States.

91. Adaptation of Related Species.—Speaking of English conditions, Lawson says: "The hard fescues may be classed among the best native grasses for general purposes. It will thrive on a great variety of soils and produce a greater weight of fodder than might be expected from its comparative dwarf habit of growth, and is found to resist the effect of severe drought in summer and to retain its verdure during winter in a remarkable degree. It constitutes a great portion of the best natural pastures in the country, especially where the soil is light and dry." Another drought-resisting species is red or creeping fescue (*F. rubra* L.). This species on account of its creeping habit forms a close, lasting sod which is said to make it valuable on embankments where soil is dry, or for binding light sandy seacoasts.

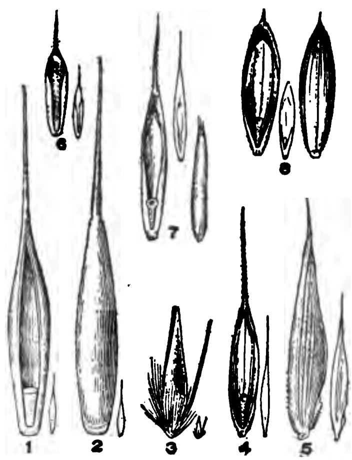
Sheep's fescue variety fine leaved taken at Cornell Station June 14. Plant grown from a single seed is 21 months old. Has not yet come into bloom. Note the fine basal leaves. Highest culms 14 inches; clump 16 inches wide.

Two other species are especially adapted to wet, moist, cold soils rich in humus—namely, various leaved fescue (*F. heterophylla* L.) and floating fescue (*F. fluitans* L.). The latter is recommended for shady places, and is said to be valuable as a constituent of permanent meadows either for mowing or grazing. The seed of all the six species just mentioned is high-priced and none is recommended for general culture, although special circumstances or conditions may arise where they will be valuable.

92. Distribution.—There are about 80 species of Festuca widely scattered throughout the world, but especially in the temperate regions. While a number of species are native of North America, meadow fescue is introduced. It is one of the chief cultivated grasses of Great Britain and the continent of Europe, but it has been sparingly cultivated in North America. According to Spillman, its cultivation has reached some importance in eastern Kansas and western Missouri, where a considerable amount of seed is produced; while in Washington, Idaho, and Oregon it is regarded favorably. It does not seem to have been seriously tried in the North Atlantic states; but judging from the way it is spreading in places where it has escaped from cultivation or where it has been sown in permanent pastures, there is reason to believe that on rich soils in the cooler climates of northern United States and in Canada it could profitably form a part of the mixture for permanent pastures.

Spikelet of tall meadow fescue. Enlarged two times.

93. Adaptation.—Meadow fescue is about equally adapted to pasture or meadow, although in the timothy region it is inferior to the latter in yield of hay. It does not have the marked tufted habit of orchard grass, nor the strongly stoloniferous or creeping habit of Kentucky blue grass, but stands with timothy somewhat between these two extremes. Nevertheless it makes a compact leafy sod, and as a pasture was found at Cornell to be distinctly more palatable to cattle than timothy if, indeed, it did not outrank Kentucky blue grass. It starts in the spring about the same time as the latter. The hay is generally considered to be both palatable and nutritious. Like Kentucky blue grass, it takes three years to form a good sod, and is therefore not adapted to temporary meadows or temporary pastures. The seed being rather high priced and rather low in germination, it is generally advisable to use it only in mixtures for permanent pastures. It is not recommended as a lawn grass. The extreme vigor with which individual plants of taller fescue developed in the trial grounds at Cornell University raises the question whether much of the inability to get a good stand of this grass is not due to poor seed.



Seeds of fescue and brome grasses. 1. Sheep's fescue (*Festuca ovina*); 2. red fescue (*F. rubra*); 3. tufted hair grass (*Deschampsia caespitosa*; 4. upright brome (*Bromus erectus*); 5. Schrader's brome (*Br. unioloides*); 6. chess (*Br. secalinus*); 7. hairy brome (*Br. asper*); 8. awnless brome (*Br. inermis*)—the small figures natural size. (After Hicks)

94. Seed.—The flowering glume or outer covering of the seed of meadow fescue is one-fifth to one-fourth inch long, is without distinct keel, and is awnless. It closely resembles the flowering glume of perennial rye grass, the latter on account of the lower price often being used as an adulterant of meadow fescue. The seed of meadow fescue is to be distinguished from perennial rye grass chiefly by its rachilla. The rachilla of the former is more slender, round instead of oval, the end having a slight knob. The rachilla also stands away slightly from the palea, while in perennial rye grass it lies close to the palea.

The standard of purity should be 95 per cent., and of germination 75 per cent., although commercial seed is frequently much lower in germinating power.

Meadow fescue is harvested for seed with a self-binder as soon as or just before seed begins to shatter and is threshed with an ordinary grain thresher. It is then re-cleaned with a sand sieve or fanning mill. While in some cases 700 to 900 pounds of seed per acre are obtained, 150 to 250 pounds per acre are considered satisfactory.

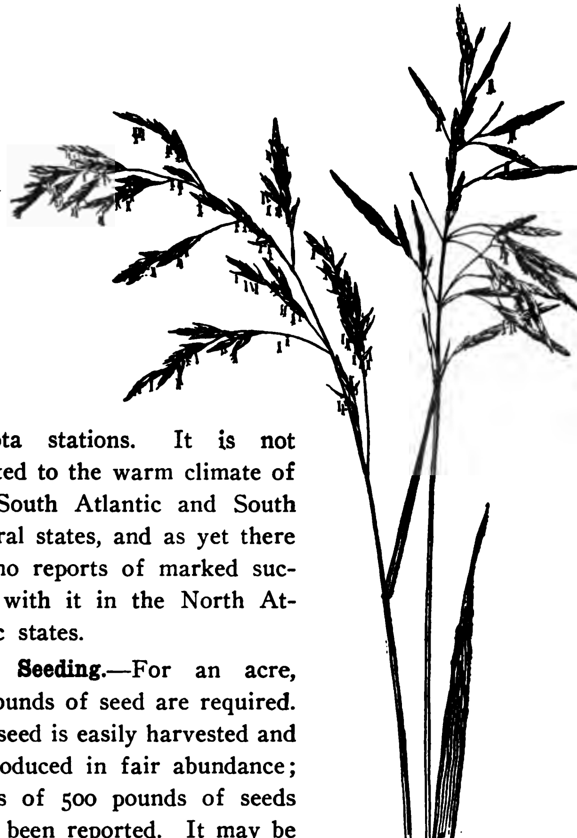
There are about 300,000 seeds to the pound. Fifty pounds of seed per acre are considered necessary, when sown alone. It is only recommended, however, for seeding in mixtures for pastures, at the rate of two to five pounds per acre.

III. SMOOTH BROME GRASS

95. Relationships.—Smooth brome grass; Hungarian brome grass (*Bromus inermis* Leyss.). This species is called smooth or awnless brome grass because it is distinguished from other forms of the genus *Bromus* by the absence of the awn on the flowering glume. This grass is closely related to cheat or chess (*Bromus secalinus* L.), from which it differs in being strongly perennial, while chess is a fall annual. (C. A. 139) Chess is rarely grown for hay. Fair yields may be obtained, but the quality is rather inferior. Schrader's brome grass (*B. unioloides* (Willd.) H. B. K.) was formerly extensively advertised under the name of rescue grass as a winter grass for the cotton states, and is now occasionally sown for winter pasture. Except in the extreme south, it does not, according to Spillman, possess for this purpose any advantages over the cereals. There is a large number of species of the genus *Bromus* growing in different parts of the United States, some of which perhaps deserve further study with a view to their introduction as cultivated plants.

96. Description.—Smooth brome grass is strongly stoloniferous and deep-rooted. At the North Dakota Station roots of one-year-old plants had reached four feet, two-year-old, five and one-half feet, forming a dense sod six to eight inches thick. The culms are erect, growing under cultivation four feet or more in height. They are abundantly provided with prominent leaves. The leaf sheath is entire; the leaf blade varies from one-fourth to one-half inch wide, 8 to 12 inches in length, and is rolled in the bud. The ligule is short and rather inconspicuous. The flowers are borne in a widely spreading panicle four to eight inches long. The spikelets are large, three-fourths to one inch long, with six to ten, usually seven to nine flowers to a spikelet. The seeds (flowering glumes) are three-eighths to one-half inch long, flat and without awns. The rachilla is one-fifth to one-fourth the length of the flowering glume and is covered with bristles which serve to distinguish the seed from perennial rye grass seed, or meadow fescue seed. The caryopsis or naked seed is brown, slightly folded, and about two-thirds the length of the flowering glume.

97. Adaptation.—Smooth brome grass being a comparatively recent introduction, its economic range has not yet been fully established for the United States. Having grown for centuries upon the Steppes of Russia, it is adapted to a cold climate and a dry soil. Although it has not been uniformly successful over the whole area, in general it appears worthy of trial over that vast area between the Missouri River and the Cascade Mountains of the Pacific coast which has not heretofore possessed a satisfactory pasture grass. Its abundant and deep root system not only enables it to withstand long periods of drought, but also by binding the particles of soil together prevents the transportation of the soil by wind. It appears particularly adapted to the sub-humid High Plains region between 98 and 104 degrees West Longitude, north of Oklahoma. It is enthusiastically recommended by the Kansas, Nebraska, and North



Meadow fescue on the left; smooth brome grass on the right. Taken at Cornell Station June 16. Both in bloom. One-third natural size.

Dakota stations. It is not adapted to the warm climate of the South Atlantic and South Central states, and as yet there are no reports of marked success with it in the North Atlantic states.

98. Seeding.—For an acre, 20 pounds of seed are required. The seed is easily harvested and is produced in fair abundance; yields of 500 pounds of seeds have been reported. It may be cut with a self-binding harvester and, after curing in shock, threshed with the ordinary grain thresher. It is recommended by the Nebraska Station that the seed be sown about as deeply as oats; shallow seeding, it is said, is a frequent cause of failure to secure a good crop. If there is plenty of moisture in the soil, it is preferably sown in the fall; otherwise spring seeding gives the best results. It is sometimes sown with winter wheat. In regions where it is inadvisable to plow on account of drifting sands it has been found practicable, by opening the ground at intervals with a spade and depositing seed, to secure such a stand of this grass as to greatly improve the existing range conditions. It is recommended to sow with alfalfa especially for pasture, the amount of pasture being increased thereby and the smooth brome grass preventing the alfalfa from bloating the cattle. (86)

Spikelet of smooth brome grass. Enlarged two times.

99. Time of Harvesting.—Smooth brome grass blooms distinctly later than Kentucky blue grass and somewhat earlier than timothy. It is said to get hard and woody rather rapidly, hence cutting as soon as it is in bloom is advised. At the North Dakota Station smooth brome grass was cut at three stages of growth—namely, (1) in blossom, (2) in milk stage, (3) when fully mature. The weight of water-free substance per acre was as follows: (1) 2,290, (2) 2,462, and (3) 2,802 pounds. Comparatively little difference in composition was found at the different stages of maturity.[1]

100. Value.—Smooth brome grass makes a good yield of hay when first seeded, but in a year or two the yield of hay falls off, apparently on account of the dense sod formed. It is thereafter best fitted for pasture, of which it furnishes a great abundance. It starts early in the spring, grows late in the fall, and withstands drought best of any cultivated forage grass. The hay is readily eaten by horses, cattle, and sheep, and the pasture is extremely palatable. At the Cornell Station cattle

[1] North Dakota Sta. Bul. No. 47. 1901.

appeared to prefer it as pasture to Kentucky blue grass, meadow fescue, or any other cultivated grass.

Smooth brome grass is highly prized as an improver of soils too long cultivated in cereal crops, since the great mass of roots and underground stems and the dense mat of vegetation on the surface make a marked addition to the organic matter of the soil, adding to the water-holding capacity of the soils in the sub-humid sections. Being strongly stoloniferous, it is a plant of good duration.

Smooth brome grass taken at Cornell Station June 22. Plant passing out of bloom. Highest culms 48 inches; clump 24 inches wide; 21 months old from single seed. Note the upright character of the leaves as compared with tall fescue or orchard grass. Note also the large spikelets.

IV. BERMUDA GRASS

101. Description.—Bermuda grass (*Capriola dactylon* (L.) Kuntze) is strongly stoloniferous, spreading by both above ground and underground stems, making a dense, thick sward which stands tramping well. The flowering culms vary from a few inches to two feet in height under favorable conditions. They are sparingly supplied with leaves and bear three to five one-sided spikes. The spikes, one to two inches long, bear one-flowered spikelets, which mature seed sparingly in the United States, except in the extreme southern portion.

102. Seed.—The seed is imported and apparently unreliable. There are 1,800,000 seeds to the pound. On the Potomac Flats at Washington, D. C., a dense sod was obtained in ten weeks by seeding on June 6 with 20 pounds of seed per acre.[1] It is believed eight pounds of seed per acre are sufficient to secure a fair stand. Spillman states, however, that for Bermuda grass seed "to germinate, the conditions must be exactly ideal." It is usually propagated by cutting up the sods, sowing the pieces broadcast, and plowing in or planting in rows or hills like potatoes. In fact, any method of distributing and covering the pieces of stems will suffice. Seeding may be done at any time except when there is danger of freezing. Spring is to be preferred.

Velvet grass taken at Cornell Station June 14. Plant grown from a single seed is 21 months old. In full bloom. Highest culms 22 inches; clump 20 inches wide.

103. Adaptation.—Bermuda grass is a tropical plant, and has no agricultural value north of the thirty-seventh parallel. South of the thirty-fifth parallel it is a valuable grass both for hay, pasture, and lawns, as well as for the prevention of the erosion of the soil. It stands the hottest weather and severe drought, making its best growth in the summer months. It does not thrive in the shade. It starts late in the spring, and in the fall the tops are easily killed by frost. In order to secure pasture throughout the year in the Gulf states, attempts

[1] U. S. Dept. Agr., Div. Agros. Circ. No. 28, p. 4

have been made to sow bur clover (*Medicago maculata* Willd.) or hairy vetch on Bermuda sod in September (using disk harrow to open the soil) with rather indifferent success. A variety known as St. Lucie is said to be more frost-resistant, and hence, on account of keeping green longer, is preferred as a lawn grass. It is also said to be more easily exterminated. Bermuda grass thrives upon a great variety of soils, but is probably best adapted to sandy soils.

104. Value.—Bermuda grass is liked by domestic animals either as pasture or as hay. Analyses also indicate that it is highly nutritious. While on fertile soils it may be cut two or three times in a season and may under favorable conditions yield two to four tons of hay per acre, its habit of growth best fits it for grazing. For this purpose, it is the standard grass in the cotton states. Bermuda grass and Japan clover are pre-eminently the pasture plants of the South. Bermuda grass is, however, less extensively cultivated than would seem to be indicated by its excellent qualities. This may be due to the high price of the seed, or to the fact that the plant takes such a strong hold upon the soil as to make it unsuited to short rotations. Where it seeds freely, it is said to become a serious pest. Where it does not produce seed it can be controlled by plowing and growing a thickly sown and strong growing crop, such as sorghum, millet, oats, cowpeas, or velvet beans.

V. MINOR GRASSES

105. Johnson Grass (*Sorghum halepense* (L.) Pers.) is a strongly stoloniferous, coarse-growing plant, with culms four to seven feet high, bearing long, broad, flat leaves and having an open panicle 6 to 18 inches long. The spikelets are in pairs at the nodes or in threes at the end of the branches, one sessile and perfect, the others pedicelled and empty. The sessile spikelets are one-seeded. From 25 to 40 pounds of seed may be sown to the acre. While it is hardy as far north at least as the fortieth parallel, as a weed it is usually met only in the cotton states, and especially on the black prairie

limestone soils in that section. It will thrive under a wide range of climatic conditions both as to temperature and moisture.

Johnson grass is closely related to the millets and sorghum, it being considered the parent form of the latter by Hackel. It is not of the highest feeding value, being similar to the millets in this regard. (119) In some sections where other grasses do not thrive, it has been found profitable to give up the farm to producing Johnson grass hay. Two or three cuttings may be obtained in one season. Like other strongly stoloniferous grasses, it becomes sod-bound in two or three years, thus reducing the yield. Spillman recommends plowing the meadows in the fall every two years. By this method meadows are said to continue productive as long as fertility lasts. Johnson grass does not stand grazing well, pasturing sometimes being recommended as a means of eradication.

Tall oat grass taken at Cornell Station June 15. Panicle in bloom. One-third natural size

Johnson grass can scarcely be considered a cultivated grass, since it is usually self-sown. It is difficult to eradicate completely, both because of its strongly stoloniferous habit and because it seeds freely.[1] It is therefore ordinarily looked upon as a major weed and a minor cultivated plant. Doubtless, however, it may come to occupy an important place in the farm economy in certain sections of the South Central states.

106. Tall Oat Grass (*Arrhenatherum elatius* (L.) Beauv.) is closely related to the common cultivated oat, and also to the common wild oat-grass (*Danthonia spicata* (L.) Beauv.) which forms a not inconsiderable portion of the herbage of permanent pastures and meadows on the poorer soils of the North Atlantic states. The tall oat grass is a fibrous-rooted, erect, tall grass, growing on suitable soil three to five feet high, with a long open panicle bearing two-flowered spikelets. It yields an abundance of coarse forage, and will grow on rather sandy soils where other grasses do not thrive so well; but in the United States its lack of palatability has prevented its extensive cultivation. (8) It is known in France as ray grass where, as in other parts of Europe, it is highly prized. The seed is principally imported,

[1] For methods of extermination, see U. S. Dept. Agr., Bu. Pl. Ind. Bul. No. 72, pt. 3.

but can be easily harvested. It may be bound, cured in shocks, and threshed as in case of common oats. There are 159,000 seeds to the pound. About 50 pounds of seed with a germinating power of 70 per cent. are required to sow an acre.

107. Velvet Grass (*Holcus lanatus* L.) is an early flowering grass, growing 18 to 30 inches high. It is characterized by the downy character of the

Velvet grass taken at Cornell Station June 15. Spray on the left in full bloom; in the middle in bloom at top; on right not in bloom. One-third natural size.

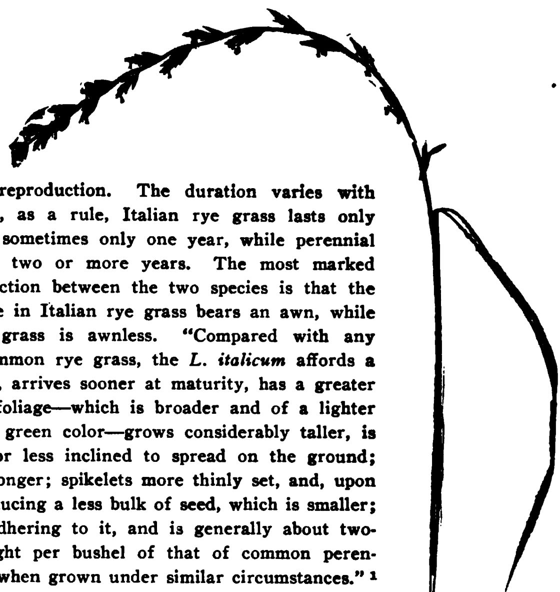
Sweet vernal grass taken at Cornell Station June 16. Lower spikelets in bloom. Slightly reduced

leaves, from which it takes its name and which makes it of little value, since this character makes it unpalatable to live stock. It grows rather readily, and is said to be especially adapted to soil high in organic matter and moisture. It is distinguished from other commonly cultivated grasses by the soft woolly appearance of its rather large panicles. In Scotland this plant commonly occurs in perennial rye grass, and commercial seed is obtained in cleaning the latter seed. The commercial seed usually consists of the two-flowered spikelets. The germination is low—50 per cent. or less. About 20 pounds of seed are required per acre.

108. Sweet Vernal Grass (*Anthoxanthum odoratum* L.) is a fibrous-rooted grass, growing 12 to 18 inches high. It is characterized by its agreeable

odor and bitter taste. It is adapted to dry pastures, and it is said that in England in those pastures where this grass is abundant, the finest mutton is produced. There seems to be plenty of evidence that cattle and even sheep are not fond of it. It has been widely tested by the experiment stations and is probably of little, if any, value. The seed is principally gathered in central Germany from wild plants growing in the woods. There are 924,000 seeds to the pound. The germinating power is low—30 per cent. or less—and 30 pounds of such seed would be required to seed an acre.

109. PERENNIAL RYE GRASS (*Lolium perenne* L.) and Italian rye grass (*L. italicum* A. Br.) are not properly included under perennial forage grasses, since neither is strictly perennial. Both species are intravaginal and tufted, and have rather limited power of vegetative reproduction. The duration varies with conditions; but, as a rule, Italian rye grass lasts only two years and sometimes only one year, while perennial rye grass lasts two or more years. The most marked botanical distinction between the two species is that the flowering glume in Italian rye grass bears an awn, while perennial rye grass is awnless. "Compared with any varieties of common rye grass, the *L. italicum* affords a stronger braird, arrives sooner at maturity, has a greater abundance of foliage—which is broader and of a lighter or more lively green color—grows considerably taller, is more upright or less inclined to spread on the ground; its spikes are longer; spikelets more thinly set, and, upon the whole, producing a less bulk of seed, which is smaller; has the awn adhering to it, and is generally about two-thirds the weight per bushel of that of common perennial rye grass, when grown under similar circumstances." [1] Italian rye grass grows somewhat taller (one and a half to three feet) than perennial rye grass (one to two feet) and is characterized by its very rapid growth. It is extensively used for meadows in England, and is especially adapted to rich, moist soils and to sewage irrigation. Perennial rye grass is grown both for hay and for grazing, but is perhaps best adapted to pastures of short duration.



Perennial rye grass taken at Cornell Station June 16. Spike in bloom. One-third natural size.

Both species produce seed abundantly, and the seed is therefore cheap. Germination in commercial seed is about 75 per cent. The size of seeds is

[1] The Lawson Seed and Nursery Company: Agrostographia, p. 29.

quite variable, but Stebler gives the average number of seeds per pound for Italian rye grass 285,000, and for perennial rye grass 336,000. About 50 pounds of seed are sown per acre when sown alone, but usually perennial rye grass is sown in mixtures, not to exceed 10 per cent. of the whole being recommended. The above statement is for European, and especially English, conditions. Where tested in America, the yield of forage has been too small to make either species valuable.[1]

Practicums

110. EQUIPMENT FOR THE STUDY OF GRASSES AND OTHER FORAGE CROPS.—The equipment for teaching grasses and forage crops should consist of the following materials:

1. A grass nursery consisting of at least 50 individual plants of each of the species it is desired to study. These should be started in small pots in the greenhouse and planted in rows 5 feet apart, with the plants 40 inches apart in the rows. There should be not less than two rows nor more than three to each plat or species and every third or fourth plat should be planted to some standard plant, like timothy for the grasses and red clover for the legumes, for purposes of comparison. This nursery serves as a place where students may study the gross characters of the different species and their habits of growth. No other kind of instruction can fully take the place of this field study. The information to be obtained will be valuable to the instructor as well as to the student. The nursery also serves to furnish fresh specimens annually for indoor study,—a very essential feature of successful laboratory instruction.

2. Every student should be furnished with a bundle of each species to be studied. Each bundle should be the complete product of a single plant from the grass nursery gathered when seeds are well formed but before the plant has become fully ripe. By this means the student will be enabled to judge of the relative possible production of single plants of the different species.

3. Each student should be furnished with a pressed and mounted specimen of each species gathered at the time of full bloom. These should be placed upon jute tag board, 120 pounds to the ream, 22x28 inches. The specimens may be sewed on the paper or fastened with adhesive cloth.

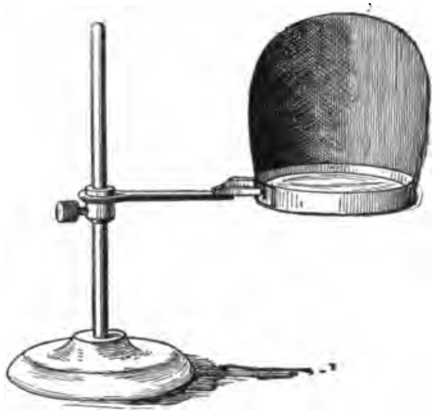
4. The laboratory should contain a full collection of seeds of the plants to be studied, as well as seeds of related economic plants and weed seeds commonly occurring in commercial seeds. (See practicum on seed testing.) (115)

5. Laboratory desks with water and gas may be arranged with five-foot frontage for each student and 30 inches deep by 30 inches high. Two thirty-inch drawers and cupboards on either side of the knee space may serve for holding mounted specimens, the smaller bundles, and apparatus. The larger

[1] For detailed account of the rye grasses, see Stebler and Schröter: The Best Forage Plants, pp. 20–30.

bundles may be placed in the locker with which every student should be provided. This desk will, by having classes in sections, accommodate two students.

6. A large amount of the essential study of grasses and forage crops may be accomplished without any microscopic equipment. The important requirement for lenses for this work is a rather large field. If each student is provided with a one-inch focus lens, the other requirements may be met by a few lenses or microscopes placed upon side tables where students may use them as needed. The following are suggested as useful: (1) reading glass and stand consisting of lens 4 inches in diameter with a focus of 9 inches; (2) dissecting microscope with one and a half and three-fourth-inch lenses (such as Bausch & Lomb's No. 2); (3) a compound microscope with one and two-inch eyepieces and two-inch, two-thirds-inch and one-sixth-inch objectives (such as Bausch & Lomb's Stand BB). Each student may be furnished with the dissecting microscope just mentioned, but when this cannot be afforded, a simple dissecting microscope (such as Bausch & Lomb's S3) will be found useful.



A desirable reading glass for examining seeds

7. Students should have access to bulletins of the experiment stations, and there should be at least one set of the *Experiment Station Record* for each 20 students. For list of books, see outline for discussion of grasses and leguminous forage crops. (111)

111. Outline for Discussion of Grasses and Leguminous Forage Crops.—The author has for a number of years required students to make an individual study of specimens of forage crops and of a selected list of station publications, together with some of the more useful books used as reference merely. Below is submitted an outline which experience has shown to work satisfactorily. Students have been able to complete the outline on grasses in six weekly practicums of two and a half hours each by writing up the notes outside the practicum hours; if done separately, legumes will require about an equal amount of time, but if the work follows the grasses, it may be completed in somewhat less time. For leguminous forage crops see 253.

There are two sources of information: (1) the plants, and (2) references to certain publications. References are of two kinds: (1) books containing a general discussion, and (2) *Experiment Station Record* containing references to experimental results. References to the *Experiment Station Record* are given under each head by volume and page. If a more extended account is desired, consult the reference therein mentioned.

Books—

Beal: Grasses of North America.
Coburn: Alfalfa.
Coburn: The Book of Alfalfa.
Flint: Grasses and Forage Plants.
Hackel: The True Grasses.
Howard: Grasses and Forage Plants at the South.
Shaw: Forage Crops Other than Grasses.
Shaw: Soiling Crops.
Shaw: Grasses and Clovers.
Shaw: Clovers and How to Grow Them.
Spillman: Farm Grasses of the United States.
Stebler and Schröter: The Best Forage Plants.
Vasey: Agricultural Grasses of North America.
Wallace: Clover Culture.
Ward: Grasses; A Handbook for Use in the Field and Laboratory.
United States Department of Agriculture: Bulletins of the Division of Agrostology.

Description—

Describe the roots, culms, leaves, inflorescence, and seed of timothy, red-top, orchard grass, meadow fescue, Kentucky blue grass, and smooth brome grass. Place special emphasis upon those characteristics which give them agricultural value. II, 329[1]; IV, 249; VI, 403, 691; XI, 120, 420, 423, 927; XII, 517; XIII, 224, 443; XVII, 23.

Adaptation—

Discuss the actual distribution of various species of grasses and the influence of climate, soil and demands upon such distribution. II, 69, 329; VI, 403; IX, 242; XI, 43, 339, 1033; XII, 332; XIII, 443, 526. See also Twelfth Census, 1900, Vol. VI.

Seed—

State quantity of seed, number of live seeds required per acre, standard of germination, common impurities, and manner and time of sowing of six species above named. I, 23, 25, 286; II, 69, 329, 511, 601, 632; III, 217, 785; IV, 720; V, 333, 334, 628; VI, 641; IX, 829, 956; X, 836; XI, 120, 155, 156, 339, 462; XII, 535, 565; XIII, 564; XIV, 139, 241; XVI, 785; XVII, 241, 546, 547, 653, 763, 964.

[1] Roman figure refers to volume of *Experiment Station Record*, Arabic figure to the page of the volume.

Cultural Methods—

General: I, 183, 254; II, 237, 594, 600; III, 28; IV, 248, 646; V, 38, 171, 577, 679, 680; VI, 290, 415, 531; VIII, 307; IX, 335, 553, 829; X, 431; XI, 145, 339; XII, 138, 629; XIII, 442, 1039; XIV, 139, 240, 241; XV, 132, 237, 665; XVI, 141, 144, 149, 249, 447, 864, 968.

Mixing with other crops: I, 183, 254; II, 511, 594, 601, 602, 633; III, 836; IV, 38, 249; V. 171; VI, 138, 290; IX, 829; X, 431; XI, 743; XII, 347, 535, 740; XIII, 751; XIV, 574; XV, 138, 237, 1068; XVI, 249, 472; XVII, 128.

Fertilizers: I, 183; II, 580, 602, 633; III, 376; IV, 28, 129, 133; V, 291; VI, 405, 720; VIII, 778; IX, 829; X, 626; XI, 136, 141, 145, 530, 539, 641, 642, 722, 835; XII, 228, 634, 739, 935; XIII, 333; XIV, 32, 134; XV, 32, 139, 140, 665; XVI, 350, 502, 963, 968; XVII, 235, 412, 461, 1141.

Rotation: XIII, 34; XVI, 150.

Harvesting: I, 34; II, 328, 486, 740.

Value—

As indicated by yield or growth: II, 69, 511, 633, 740; III, 128, 455; V, 38; VI, 532; IX, 829; X, 626, 838; XI, 339; XII, 547, 629, 634; XIV, 33; XV, 145, 350; XVI, 131, 354, 864; XVII, 272, 352, 380, 895.

As indicated by feeding trials or otherwise: I, 183, 270; III, 160, 454; IV, 29, 480; V, 76, 172, 330; VI, 405, 532; IX, 242, 828; XI, 28, 420, 632, 1033; XII, 547; XIV, 240.

112. Outline for Study of Vegetative Portion of Grasses in the Field. —For this practicum, single specimens should be grown in the grass nursery. The specimens may be examined as they occur in the nursery or may be placed in pots and taken to the laboratory. The following eight grasses are recommended: timothy, meadow foxtail, redtop, Kentucky blue grass, Canadian blue grass, orchard grass, meadow fescue, and smooth brome grass.

Latin name........................Common name.....................

Where found........................Date ....

Student's name ....

Leaf sheath: Round; elliptical; lenticular: smooth; downy; rough: split to node; partly split; entire; length.............inches to.............inches.

Ligule: Long; medium; short: acute pointed; obtuse pointed; truncate; rectangular: serrated edges; not serrated.

Leaf blade: Erect; ascending; drooping: smooth; downy; rough: rolled or convolute in bud; folded or conduplicate in bud: color...........; length ....inches to.............inches.

Midrib: Prominent; medium; small.

End of blade: Acuminate; tapering; obtuse; parallel sided. (Compare redtop with Kentucky blue grass.)

Color of roots: White; brown; red.

Lower internode: Normal; thickened.

Habit of growth: Intra-vaginal; extra-vaginal: no stolons; short stolons; long stolons.

Diameter of single plant: ....inch to.............inch.

113. Outline for Study of Mature Grasses.—Either fresh or dried specimens may be used for this practicum. If the latter, both single mounted specimens and bundles of grasses are desirable. The following eight grasses are recommended: timothy, meadow foxtail, redtop, Kentucky blue grass, Canadian blue grass, orchard grass, meadow fescue, and smooth brome grass.

Latin name..........................Common name.......................
Where found........................Date ....
Student's name ....

Culm: Height in inches..............

Culm: Erect and ascending at base; erect but decumbent at base; decumbent.

Culm: Strong; medium; slender.

Culm: Round; elliptical; lenticular.

Culm: Strongly furrowed; medium furrowed; not furrowed.

Culm: Color..............

Culm: Foliage abundant; scanty.

Cross section of upper part of culm: Solid; nearly solid; hollow: walls, thick; medium; thin.

Leaf sheath: Smooth; downy; scabrous.

Leaf sheath: Split to node; partly split; closed.

Leaf sheath: Relation of length of leaf sheath to length of leaf blade ....; constant or variable.

Leaf sheath: Color.

Ligule: Large; medium; small.

Leaf blade: Length (average of five)..............; width (average of five)..............

Leaf blade: Midrib, prominent; medium; indistinct.

Leaf blade: Veins, prominent; medium; indistinct.

Leaf blade: Open; folded.

Inflorescence: Number of flowers per spikelet..............: outer glumes, longer than flowering glume; shorter: flowering glume, hyaline; chartaceous.

Panicle: Open and spreading; compressed or tufted; spike-like: length of panicle..............

114. Seed Identification.—Supply each student with one gram of a commercial sample of seed of timothy, redtop, orchard grass, Kentucky blue grass, meadow fescue, perennial rye grass, and smooth brome grass. Student should be supplied with a magnifier about five diameters, needle, cross section paper, and a few sheets of white paper. Determine the following:

1. Pure seed: No..............Weight..............
2. Weed seeds: No............No. of kinds............Weight..........
3. Foreign but useful seeds: No..............No. of kinds.............. Weight..............
4. Inert matter: Weight..............
5. Flowering glume: Length: Determine when placed end to end number required to cover five inches. Caryopsis: length..............

6. Flowering glume: Blunt; pointed: straight; curved: awned; awnless.

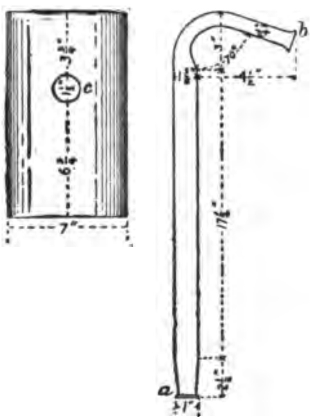
7. Flowering glume: Yellow; brown; reddish; silvery: chartaceous; hyaline.

8. Flowering glume: Keel: prominent; medium; absent: smooth; hairy. Adherence: strong; medium; weak.

9. Rachilla: Long; short; variable: slender; broad: smooth; hairy: standing away from the paleae; compressed against paleae; absent.

10. Most important character for identification..............

115. Seed Test.—Give each student samples of commercial seed representing considerable differences in the percentage of germination. The following grasses are suggested: redtop, Kentucky blue grass and timothy, each one ounce; red clover, alfalfa and meadow fescue, two ounces; hairy vetch and cowpeas, each four ounces. For details, see Rules and Apparatus for Seed Testing, adopted by the standing committee on methods of seed testing of the Association of American Agricultural Colleges and Experiment Stations. U. S. Dept. of Agr., Off. Expt. Sta. Circ. 34 (Revised). The following special apparatus in addition to lenses, microscopes, and dissecting instruments is recommended:



Vertical air blast separator

1. A seed mixer and sampler.
2. A nest of small copper sieves.
3. A vertical air-blast seed separator.
4. An authentic collection of the seeds of the principal weeds and cultivated plants such as is prepared for schools by the Seed Laboratory of the U. S. Dept. of Agr.
5. Standard or Semoer's germinating chambers equipped with low temperature thermostats and thermometers.
6. Blue blotting paper and canton flannel.
7. Sterilized sifted sand and shallow greenhouse flats.

Purity Test—

Sampling: Take from each sample of redtop and Kentucky blue grass, one gram; of timothy, two grams; of meadow fescue, three grams; and of red clover and alfalfa, five grams in such manner as to make them thoroughly representative of the sample submitted. (16)

Separation: Divide sample just taken into three parts and weigh each part as follows: (1) inert matter; (2) all foreign seed except adulterants; (3) pure seed and adulterants. First use vertical air-blast separator to separate chaff and seeds of different specific gravity, then use sieves to separate seeds of similar specific gravity, but of different sizes; then complete separation by hand.

Adulteration: From the mixture of pure seed and adulterants count out 1,000 seeds indiscriminately, then separate adulterants from pure seeds, recording number and weight of each.

Weed seeds: Separate and identify foreign seeds other than adulterants; where a kind constitutes less than 1 per cent. report by number, where more than 1 per cent. report the percentage by weight.

Germination Test—

Sampling: Thoroughly mix the entire amount of pure seed obtained in making the purity test and select 200 seeds of redtop, Kentucky blue grass, timothy, meadow fescue, red clover, and alfalfa; 100 seeds of hairy vetch and cowpeas for each of the duplicate tests.

Placing seeds: Put seeds of redtop, Kentucky blue grass and timothy *on top* of blotters made by folding twice lengthwise strips 6x19 inches cut from blue blotting paper, 120 pounds to the ream and free from injurious chemicals. The blotting paper should be used once only. Put other seeds *between* strips 8x32 inches of medium weight canton flannel folded twice lengthwise. The flannel must be sterilized by boiling each time before using.

Management test: Place seed in germinating chamber at 68° F. (20° C.) for 18 hours and 86° F. (30° C.) for six hours. Keep paper or cloth well moistened with potable water at the temperature approximately of the chamber.

Counting sprouts: Remove sprouted seeds and record number every second or third day (three times a week). In the case of legumes, count the remaining hard seeds and add one-third to the number of viable seeds.

Duration test: For grasses, 14 to 28 days; for legumes, 7 days.

Re-test—

If duplicate tests vary more than 10 per cent., re-test and also make a supplementary test.

Supplementary test: Place in a greenhouse flat sterilized sand free from organic matter, sifted to a uniform size of approximately one millimeter. Place redtop, Kentucky blue grass, and timothy on top the sand; plant other seeds at a depth about equal to twice their greatest diameter. Place in room with alternating temperature as previously indicated. Keep moist and shaded. Count only sprouts which occur above ground. The supplementary test should be accepted when it shows a higher germination than the chamber test.

Report: Make a report of all data obtained; state the per cent. of viable pure seeds found by multiplying the percentage of pure seeds by the percentage of total germination of the pure seeds.

116. Collateral Reading.—F. G. Stebler and C. Schröter: The Best Forage Plants, pp. 30-38. London: David Nutt, 1889.

William Jasper Spillman: Farm Grasses of the United States, pp. 154-178. New York: Orange Judd Co., 1905.

Thomas Shaw: Grasses and Clovers, Field Roots, Forage and Fodder Plants, pp. 14-17. Minneapolis: Northrup, Braslan, Goodwin Co., 1895.

R. A. Oakley: Orchard Grass. U. S. Dept. Agr., Bu. Pl. Ind. Bul. 100, part VI, 1906.

P. Beveridge Kennedy: Smooth Brome Grass. U. S. Dept. Agr., Div. Agros. Circ. No. 18, 1899.

A. S. Hitchcock: Bermuda Grass. U. S. Dept. Agr., Div. Agros. Circ. No. 31, 1901.

VI

ANNUAL FORAGE PLANTS

117. Annual Forage Plants are a class of annuals which are characterized by the production of abundant vegetative growth during the first year from seeding. An essential feature of a successful annual forage plant is that it should produce seed abundantly and cheaply, in order not to make the cost of seeding too expensive. This is more important than with perennial forage crops, where a single seeding produces two or more crops. The mere fact that an annual plant makes a high yield per acre does not necessarily commend it for general cultivation.

Ordinarily this class of plants enters into American farm economy incidentally. Thus the cereals produce as by-products large quantities of straw and stover used as food and bedding for domestic animals. In certain portions of the United States where the standard perennial forage grasses are less successful the cereals are frequently harvested for hay. In 1900, 6 per cent. of the area in hay and forage crops consisted of cereals cut green, not including the large acreage of maize cut for silage or fodder. More than half the acreage of the smaller cereals used for hay is in California, Oregon, and Washington, and consists chiefly of barley and wheat. In other portions of the country oats are used, and in Canada especially the sowing of oats and peas to be cut for soiling or forage is not uncommon. (C. A. 405) In eastern United States rye is also used for soiling purposes. (C. A. 491)

In addition to the common cereals, the millets and other closely allied plants are grown in various parts of the United States for forage. These are usually grown as "catch" crops, or for the purpose of supplementing the usual supply of hay and forage. In 1900 rather less than 3 per cent. of the area in hay and forage was devoted to the millets—excluding sorghum and kafir corn, which are grown for forage as well as for sirup or seed. (C. A. 559) The millets are most largely grown at present in Kansas, Nebraska, Missouri, Iowa, and the Dakotas, but would seem well adapted to the farm economy of the southern states, both because of their climatic adaptation and because the standard perennial forage plants are less adapted to that section.[1]

118. Millets.—The number of species known as millets is very large and includes nearly all the grasses whose grain is used for human food, with the exception of wheat, rye, oats, barley, and rice—even maize in some countries being sometimes called millet. Excluding the sorghums, the millets cultivated more or less commonly in America may be divided into four groups: (1) foxtail or common millet, (2) broom corn millet, (3) barnyard millet, and (4) pearl millet.

Of these, foxtail millet is by far the most commonly cultivated. In fact, the other forms can scarcely be considered to have entered into general cultivation. In this country millets are grown almost exclusively for forage. Broom corn millet is sometimes grown for its grain, and slight quantities of foxtail millet are used for bird seed. In Asia, however, millet seed is a common article of diet, it being estimated that one-third of the population of the globe use millet seed of various kinds.[2]

119. Foxtail Millet (*Chaetochloa italica* (L.) Scribn.) is divided into three types: Hungarian grass, common millet

[1] Some of the annual forage plants have been treated elsewhere in this volume or in "The Cereals in America," and will not be considered in this chapter.

[2] For species of millet grown in various parts of the world for seed or forage, see Michigan Sta. Bul. No. 117 (1894), pp. 50-64.

German millet, which may be distinguished by the size, form, and compactness of their spikes and the form and color of their seeds. The Michigan Station thus describes the three types[1]:

Hungarian grass. Stems several from each root, slender, somewhat inclined to branch; leaves rather narrow, upright, dark green; heads erect or nearly so, about four inches long, oblong, dark purple, bristly, very compact; seeds oval, purple, mixed with more or less yellow grains due chiefly to imperfect maturity. Season medium.

Common millet. Stems several from each root, slender, seldom branching;

Common German Hungarian

Cultivated varieties of foxtail millet
(After Crozier)

leaves rather broad and lax; heads nodding, about 6 inches long, tapering gradually toward the end, moderately compact above but loose and open at the base showing the lateral branches of which it is composed, color green, turning to a yellowish brown when ripe; seeds large, yellow, oval. Season early.

German millet. Stems single, or at most a few from each root, large and stout, unbranched; leaves rather short, broad, and stiff; heads usually nodding, an inch in diameter, six to eight inches long, composed of clustered branches with purplish awns; seeds small, round, of a yellow or golden color. Season late. A northern strain has more slender stems, smaller and more compact heads, oval seeds, and somewhat earlier maturity.

[1] Michigan Sta. Bul. No. 117 (1894), p. 5.

Other names used for types more or less closely related to the above are golden millet, Italian millet, Japanese millet, and California millet. The original or wild type of the foxtail millet is believed by Hackel to be the well-known foxtail weed (*Chaetochloa viridis* (L.) Scribn.). The foxtail millets grow erect like the smaller cereals, and under cultivation are from two to five, usually three to four feet in height.

These millets are hot weather plants and are exceedingly drought resistant. While they thrive best on fertile soils, they will grow on relatively poor soils. They are better adapted to sandy than to clay loams. Under proper conditions of heat and moisture full crops may be obtained in six to ten weeks. They are generally considered an exhaustive crop, perhaps because the rapid growth temporarily reduces the soil moisture. They are good crops for subduing weeds, especially when sown in hot weather, and are not infrequently used for this purpose. These millets are subject to the same diseases as sorghum, but are usually rather free from fungous diseases or insect enemies. (C. A. 533)

Because of slowness of germination and early growth, seeding should not occur until continued warm weather is assured. In the North Central states sowing in June and July gives the best results. The number of seeds varies from 175,000 to 250,000 per pound. Ordinarily 48 pounds of Hungarian grass seed and 50 pounds of millet seed are sold for a bushel. The amount of seed sown per acre varies from one to four pecks, a moist clay soil requiring a heavier seeding than a dry sandy one. A common practise is to sow three pecks. At the Michigan Station, one peck per acre produced a heavier yield of hay than more or less seed. On the clay soil the seed did not germinate so well; otherwise the lighter seeding would probably have given the best results.

When sown broadcast for seed, not more than one peck should be used. Better seed can be obtained by sowing thinly in drills and cultivating between the rows. Millet may be harvested and handled as any cereal and threshed with a grain separator, using a clover screen and a light draft. (C. A. 166) The average yield of seed per acre is estimated at 20 bushels, although a yield of 85 bushels has been reported. Yields of from one to two tons as a "catch" crop, and, under favorable conditions, from three to five tons of well-cured hay per acre, may be obtained. Millet cures rather slowly, but when properly stacked will stand considerable rain without material injury. Where live stock, especially horses, are fed largely or too exclusively on millet hay, ill effects are sometimes observed, because of the action of the millet upon the kidneys. The short, stiff hairs or bristles so abundant in the spike may cause injury in some cases. For these reasons millet should be cut before the seed is well formed and should not form the exclusive roughage of domestic animals. When harvested sufficiently early and fed in moderation, millet hay makes a nutritious and desirable food for horses, cattle, and sheep.

120. Broom Corn Millet (*Panicum miliaceum* L.) is the species which is chiefly grown in Europe and hence is there known as common millet. It has been given the name broom corn millet in this country because the inflorescence is a panicle, as in broom corn, instead of a spike, as in foxtail millet. The leaves and stems are covered with stiff hairs. As compared with foxtail millet, the seeds are larger, rather more than half the number per pound, and may be white, yellow, or red, sometimes nearly black in color. Usually it does not grow as tall as foxtail millet and produces rather less forage and more seed or grain. It may be sown later in the season or farther north. Because of its ability to mature a crop of seed in short, hot, dry seasons, it has been grown in the Dakotas and adjacent sections as a substitute for maize, and hence is sometimes called hog millet. It is said not to have the diuretic effect of foxtail millet.

121. Barnyard Millet (*Panicum crus-galli* L.) is the common annual barnyard weed usually called Barnyard grass. As a weed it is widely distributed throughout the United States, and, in fact, all the warmer parts of the world. In some sections of Mississippi and Florida it makes a good part of the volunteer growth which is used for hay.[1] It varies widely in size, form, color, and time of maturity. While usually more or less prostrate, some forms grow quite erect.

Broom corn millet (after Crozier)
See 120, page 115

A large erect form of this grass, native of southwestern United States, where it is known to the Mohave Indians as "ankee," grew seven feet in height on the experiment ground of the Department of Agriculture at Washington and made a luxuriant growth at other stations. The Massachusetts Station has imported and recommends a Japanese variety of this species. It is a coarse-growing form with a heavy leafage and compact beardless heads. It matures a crop in about ten weeks, a yield at the rate of 90 bushels of seed and seven tons of straw per acre being reported.[2]

Barnyard millet does best on moist, rich lowlands, and does not endure drought well. A bushel of seed weighs 35 pounds.

[1] U. S. Dept. Agr., Farmers' Bul. No. 102, p. 9.

[2] Michigan Sta. Bul. No. 117 (1894), p. 46.

For hay one-fourth to one-half bushel of seed may be sown; for seed, somewhat less. Shama millet (*Panicum colonum* L.) and sanwa millet (*P. frumentaceum*[1] Roxb.), closely related to barnyard millet, have been tested in this country with rather indifferent results.

122. Other Panicums.—A number of other species of the genus *Panicum* deserve mention rather more because of the forage they produce through their volunteer habit than because they are cultivated.

In the Gulf states crab grass (*P. sanguinale* L.) is said to furnish more forage for home use than any other grass. This it does by the volunteer growth occurring after other crops have been removed or have matured. Colorado grass or Texas millet (*P. texanum* Buckl.), a plant much like crab grass, but larger and coarser, occurs in Louisiana and Texas, where on moist soils it is considered a satisfactory volunteer hay crop. Guinea grass (*P. maximum* Jacq.) has become established in sections of Florida and elsewhere near the Gulf coast. It is perennial, but the roots are killed if the ground freezes. It ripens seed only in the extreme south. In regions suited to it, it is highly valued for hay and pasture.

Para-grass (*P. molle* Sw.), like Guinea grass, can be grown only in regions not subject to severe frosts. It is perennial and does not produce seed in this country. It is said to furnish cuttings every six weeks between June 1 and October 1, and thereby to produce a large amount of forage.

123. Pearl Millet (*Pennisetum spicatum* (L.) R. and S.) is a coarse annual grass, six or more feet in height, bearing a long, cylindrical spike. Its principal use is as a soiling crop, and on account of its habit of stooling or suckering, it is possible on rich moist alluvial lands in the south to secure two to

[1] Index Kewensis gives *P. frumentaceum* Roxb. = *P. colonum* L., and *P. frumentaceum* Salisb. = *Sorghum vulgare* Pers.

six cuttings during a season. The plant when young is palatable to domestic animals and fairly nutritious, but if allowed to mature it is too coarse and woody to be eaten readily and is less digestible. It should be cut when two to four feet in height, four or five inches of stubble being left to permit quick renewal of sprouting. Its period of growth, three to four months, is longer than that of other millets. Yields are reported ranging from 4 to 40 tons of green forage and from 1 to 16 tons of cured hay per acre.[1] For soiling, it is sown in drills three feet or more apart at the rate of three to eight pounds per acre, depending on character of the soil, and for hay, it may be sown in drills 18 inches apart or broadcast at the rate of one-half bushel of seed per acre. Seeding is done in early April to last of May, always aiming to avoid frost. Although widely advertised under at least 18 different names,[2] it has not given general satisfaction, believed to be due, in part, to the poor quality of the seed. A bushel of cleaned seed weighs 46 to 56 pounds.

124. TEOSINTE (*Euchlaena mexicana* Schrad.).—"This is the plant of which Prof. Asa Gray said: 'Possibly affording an opportunity for one to make millions of blades of grass grow where none of any account grew before.' At the experiment stations of Louisiana, Mississippi, Georgia, and Florida, it has given the heaviest yields of any of the forage crops grown, Georgia reporting 38,000 pounds of green forage per acre, Mississippi 44,000, and Louisiana the enormous amount of over 50 tons. It needs a long season of hot weather, a rich soil, and abundant moisture in order to succeed well, and it is useless to plant it where all these conditions cannot be had. It is a remarkably vigorous grower, reaching 10 to 12 feet in height, with an unusually abundant supply of leaves and tender stems, which continue to grow until killed by frosts. If cut when it reaches 4 to 5 feet in height it makes excellent fodder, and will produce a second crop fully as large as the first. If left to grow until September or October it furnishes excellent material for the silo, in greater amount per acre than either corn or sorghum, and there are few plants which are its equal for soiling purposes. Its leaves are similar to

[1] U. S. Dept. Agr., Farmers' Bul. No. 168, p. 13.

[2] The most common synonyms of this plant on the market are pencilaria, Mand's wonder, and cat-tail millet,—so called from the resemblance of the fruiting spike to that of cat-tail or flag of marshes.

those of sorghum, but much longer, and the stalks contain from 8 to 10 per cent. of sugar. Its value for feeding and soiling is apparent from the fact that the entire crop of 50 tons per acre grown at the Louisiana Station was sold to local dairymen at the rate of $2 per ton while standing in the field. Its season of growth is so long that it seldom matures seed north of latitude 30 degrees, but it has ripened well at the Louisiana and Florida stations. The seed, 1 to 3 pounds per acre, should be planted in hills 4 to 5 feet apart each way, about cotton-planting time, and the crop cultivated like corn. The greater distance should be given on the richer soils."[1]

125 Salt-bushes.—There is a large number of introduced and native species of the genus *Atriplex,* known as salt-bushes.[2] Some are perennial, others are annual. These salt-bushes are adapted to the strongly alkaline lands in the arid sections of the United States. Australian salt-bushes, introduced into this country, are said to produce 15 to 20 tons of green food and 3 to 5 tons of dry forage per acre. It is claimed that lands slightly too alkaline for the growth of cereals may, by the growth of salt-bushes, be made to produce cereals on account of the removal of the alkali by the salt-bushes.

The seed may be sown at any time during spring and summer when the soil is sufficiently warm and moist to germinate the seed. Seeds germinate best when sown on the surface without any covering. Good results have been obtained, it is claimed, by sowing the seed on the ground when it is wet and at once driving a flock of sheep over the land.

126. Collateral Reading.—A. A. Crozier: Millet. Michigan Sta. Bul. No. 117, 1894.

Thomas A. Williams: Millets. U. S. Dept. Agr., Farmers' Bul. No. 101, 1891.

C. R. Ball: Saccharine Sorghums for Forage. U. S. Dept. Agr., Farmers' Bul. No. 246, 1906.

T. L. Lyon and A. S. Hitchcock: Pasture, Meadow, and Forage Crops in Nebraska. U. S. Dept. Agr., Bu. Pl. Ind. Bul. No. 59, 1904.

F. Lamson-Scribner: Progress of Economic and Scientific Agrostology. In U. S. Dept. Agr. Yearbook 1899, pp. 347-366.

[1] U. S. Dept. Agr., Farmers' Bul. No. 102 (1899), p. 27.

[2] Farmers' Bul. No. 108 (1900) mentions 18 species.

Jared G. Smith: Salt-bushes. U. S. Dept. Agr., Div. Agros. Circ. No. 5, 1896.

P. Beveridge Kennedy: Salt-bushes. U. S. Dept. Agr. Farmers' Bul. No. 108, 1900.

F. Lamson-Scribner: Southern Forage Plants. U. S. Dept. Agr., Farmers' Bul. No. 102, 1899.

Jared G. Smith: Grazing Problems in the Southwest and How to Meet Them. U. S. Dept. Agr., Div. Agros, Bul. No. 16 (1899), pp. 7-26.

VII

LEGUMINOUS FORAGE CROPS

I. GENERAL CHARACTERS

127. Name.—The term legume will be applied to any plant or crop belonging to the pea family (*Papilionaceae*) or to the older and more inclusive pulse family (*Leguminosae*), whether grown for seed or for forage. Those legumes grown exclusively or principally for their seeds will be considered in chapters following the discussion of those leguminous crops which are grown exclusively or principally as fodder for domestic animals. Clover as a generic term will be used to apply to the plants of the genus Trifolium—such as red clover, alsike clover—and will not be used to apply to Japan clover, alfalfa, or other leguminous forage plants.

128. Kinds.—The leguminous forage plants cultivated in America comprise for the most part clover (*Trifolium*), alfalfa and related species (*Medicago*), lespedeza or Japan clover (*Lespedeza*), soy bean (*Glycine*), cowpea (*Vigna*), velvet bean (*Mucuna*), and vetch (*Vicia*).

The soy bean and the cowpea are sometimes cultivated for their seeds, while one form of the common pea (*Pisum*) is sometimes cultivated for forage. The various forms of the bean (*Phaseolus*) and the peanut (*Arachis*) are usually cultivated primarily for their seeds or pods. While the sweet clovers (*Melilotus*) are of little value for forage purposes because of their lack of palatability, nevertheless seed is obtainable through seedsmen. Some other kinds of legumes are also advertised for forage purposes, although they have no adaptation to American conditions—or at least are confined to a very limited range. Such are milk or Chinese vetch (*Astragalus sinicus* L.), beggar weed (*Desmodium tortuosum* D.C.), sainfoin (*Onobrychis sativa* Lam.), flat pea (*Lathyrus sylvestris* L.), furze (*Ulex europaeus* L.), bird's-foot trefoil (*Lotus corniculatus* L.).

129. Common Characters.—The leguminous plants have, with few exceptions, the following characters: The leaves are alternate and spirally arranged, not two-rowed, as in grasses. The leaf consists of a long stalk or petiole and three or more leaflets. At the base of the petiole is a pair of lateral outgrowths, or the stipules. Each flower is composed of calyx, corolla, stamens, and pistil. The parts are in fives, unequal in size, and bilaterally symmetrical. The sepals

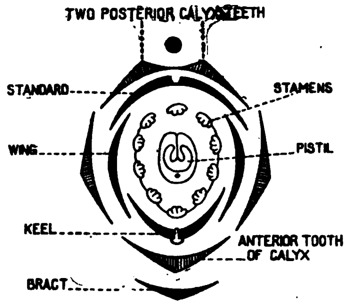


Diagram of a leguminous flower (after Eichler). Courtesy of David Nutt, London

are united; the petals are free, except in clover. The largest petal, the standard, lies between the two superior teeth of the calyx and terminates in a broad portion, the limb, which is bent upward and notched at its apex. The petals on either side are called the wings, while the two petals below, united more or less by their lower margins, are known as the keel. In the bud, the folded standard overlaps the wings, while the wings overlap the keel. There are ten stamens. Through a considerable portion of their length nine of these stamens unite by their filaments to form a tube surrounding the single pistil. The tenth and superior stamen fills up a slit in the tube. The stigma and anthers lie in the apex of the keel. The ovulary, which is one-celled, develops into a pod containing one or more seeds attached along the upper margin—that is, toward the standard. The style and stigma are single. The seeds all have the general structure described in the common field bean. (255) The legumes differ from the cereals and other seeds of the grass family in that the seeds of the latter have a small embryo, most of the seed consisting of endosperm, while the seed skin of the legumes is completely filled by the large embryo. This accounts for the highly nitrogenous character of the legumes and for the high percentage of starch in the cereals.

There is one tap root with many lateral branches, the latter mostly near the surface of the soil. So far as known, all leguminous plants bear root-tubercles or nodules on their roots under suitable conditions, from which it is inferred that all possess, with the aid of bacteria, the power of assimilating the free nitrogen of the air.

130. Variations.—Great variations in botanical characters and in habits of growth exist among the different species of legumes, and considerable variations are often found among different individuals of the same species.

In general, the plant varies in size, shape, and hairiness of the parts, and in proportion of main stem, branches, and leaves. The stems may be erect, decumbent, spreading, or trailing. Some species are strongly stoloniferous, as white clover; some slightly so, as alsike clover; and others not at all, as alfalfa. The leaflets may radiate from a common center, *palmately lobed,* as in clover; the side leaflets may be arranged along the side of the midrib, *pinnate,* as in alfalfa; and may have an even number of leaflets, *pari-pinnate,* or an odd number, *impari-pinnate.* When there is an even number of leaflets the midrib may end in a tendril, as in vetch. The stipules may be attached to the petioles or may be free. The variety of forms of the stipules constitutes one of the most distinguishing vegetative characters of the legumes, especially in the clovers.

The flowers may arise singly or may be distributed along the end of the stem or branch, a *raceme;* or may spring from the end of the stem or branch in a whorl, an *umbel;* or may be arranged along the stem or branch in a head-like cluster, a *capitulum.* In some species the flowers of the umbel or head turn downward, *reflexed,* as the seeds mature.

The anterior tooth of the calyx, the one next the keel of the corolla, varies in length when compared with the other teeth. This furnishes a means of identifying species. The petals vary throughout nearly all the colors of the rainbow. In some cases the color is quite constant within the species, as in alfalfa; in other species it is extremely variable, as in the sweet pea.

The depth to which the root grows is variable. In white clover the roots are comparatively shallow, while in alfalfa they have been reported, on what seems to be entirely reliable authority, at extraordinary depths.[1] (197) C. W. Irish reports finding alfalfa roots coming through the roof of a tunnel 129 feet below the surface of an old alfalfa field.[2]

131. Pollination.—Unlike the flowers of many members of the grass family, in which the pollen is freely distributed through the air by means of the wind, the organization of the flowers of the legumes is such that cross-pollination can occur only by means of insects or other external agencies. That pollen in some species, and, perhaps, in all species, may pollinate the stigma of its own flower, seems certain. That the showy flowers common to the legumes serve to attract insects which visit them for nectar and pollen, and thus to bring about cross-pollination, seems equally certain. Whether self-fertilization or cross-fertilization most commonly occurs is a matter requiring further investigation.

[1] J. C. Hogenson reports having found alfalfa roots at a depth of 45 feet in digging a well in northern Utah.—Thesis, Cornell University, p. 8.

[2] F. D. Coburn, "The Book of Alfalfa," p. 6.

II. ACQUIREMENT OF NITROGEN

132. Acquirement of Free Nitrogen.—Leguminous plants are characterized by containing a relatively high percentage of protein. This fact is probably, in some measure, related to the fact established by Atwater,[1] Hellriegel, Lawes and Gilbert,[2] and others that these plants possess, in connection with the micro-organisms in their nodules or root-tubercles, the ability to assimilate the free nitrogen of the air. The Kentucky Station found air-dry tubercle-bearing roots of soy beans to contain 16.9 per cent. of protein; while roots of soy beans, grown at the same time and in the same soil, but not bearing tubercles, contained but 11.3 per cent. of protein. Similar differences appear in the protein content of stem, leaves, and seeds of inoculated and uninoculated plants.[3]

The influence of the micro-organisms in acquiring nitrogen appears to be related to the available nitrogen (water soluble nitrates) in the soil. In certain soils, or under certain conditions of soil, certain leguminous plants produce tubercles very abundantly; while in other soils, or under other conditions of soil, tubercles are produced much less abundantly, although the organisms are present in both cases. It has been observed that the tubercles are produced most abundantly in soils of low nitrogen content. It is inferred, therefore, that leguminous plants acquire the free nitrogen of the air when compelled to do so, but that when soils contain an abundance of available nitrogen (water soluble nitrates) they acquire a larger proportion of nitrogen from the soil supply. The relative proportion of the nitrogen supply which these plants obtain from the

[1] W. O. Atwater: The acquisition of atmospheric nitrogen by plants. In American Chemical Journal, Vol. VI (1884-5), pp. 365-388.

[2] J B. Lawes and J. H. Gilbert: The sources of the nitrogen of our leguminous crops. In Royal Agricultural Society Journal, Vol. II, 3d ser. (1891), p. 657.

[3] Michigan Sta. Bul. No. 224 (1905).

soluble nitrates of the soil and from the free nitrogen of the air has never been determined. Nevertheless the fact that clovers and other leguminous plants do in practise improve the crop-producing power of the soils, especially for cereals and true grasses, indicates, although it does not prove, that the amount of free nitrogen taken from the air may not be inconsiderable.[1] "It is one of the secrets of profitable farming to draw from the air as much nitrogen as possible by the alternation of crops."[2]

133. Influence of Root-tubercles on the Growth of Plants.— In the case of a number of leguminous plants it has been shown that those which contain tubercles on their roots grow more vigorously than those which do not. The poorer the soil in available nitrogen the greater has been found the difference between plants possessing tubercles and those which do not. In some instances, and, perhaps, with all our more commonly

[1] There is a considerable number of facts scattered throughout the literature of the subject which may be taken, if not as an absolute, at least as a very satisfactory proof that the amounts of atmospheric nitrogen fixed may be quite large. Hall ("On the accumulation of fertility by land allowed to run wild," The Journal of Agricultural Science, Vol. I, part 2, May, 1905) shows that a portion of the Broadbalk field at Rothamsted left to itself for 20 years apparently gained nitrogen at the rate of more than 100 pounds per annum. Schultz-Lupitz (Zwischenfruchtbau auf leichten Boden, Berlin, 1901, p. 8) states that the fixation of atmospheric nitrogen by legumes is not accompanied by a reduction in the nitrogen content of the soil. One soil area at Lupitz bore 28 successive crops of lupines while receiving annually applications of kainit alone. Notwithstanding the very large amounts of nitrogen removed in the 28 crops, the soils were steadily gaining in nitrogen, as was demonstrated by the soil analyses made at different times by Maercker, Orth, Frank, and Holdefleiss. The investigations of Vogel in 1894 showed fixation of nitrogen at the rate of 140 kilos a hectare, and he estimated the total nitrogen harvest in the fall of that year (on 250 morgen) at 17,200 pounds, equivalent in round numbers to 1,100 zentners of sodium nitrate. The box experiments of the New Jersey Station (Bul. No. 180) may be taken as a further proof that leguminous crops may not only yield large quantities of nitrogen in their substance, but leave the soil richer in combined nitrogen.

[2] George Ville: Artificial Manures, p. 37.

cultivated legumes, the presence of tubercles is, in most soils, essential to a growth that is economically successful. This has been demonstrated many times with alfalfa when introduced into regions not hitherto growing alfalfa.

134. Character of the Tubercles.—The tubercles vary in shape and size with the species of plant, each species bearing tubercles that are fairly characteristic in size and form. They may be round, oval, pear-shaped, or variously lobed. They may vary in size from 0.06 inch or less to 0.31 inch or more in diameter. They are generally rather loosely attached and are readily detached when roots are pulled from the soil. They are a modification of the cell structure of the roots, caused by the presence of the micro-organism. They are softer and more juicy than the ordinary root structures. The organisms enter the plant through the root hairs, hyphae being formed which enable the bacteria to pass from cell to cell.[1]

Tubercles occur on the roots of other than leguminous plants. Some are due to the larvae of insects; others to fungi proper (mycelium-bearing cryptogams); while others may be due to bacteria. Hiltner has shown that some plants other than legumes fix nitrogen with the aid of bacteria residing in the tubercles of their roots.

135. Form of the Organism.—It is not the tubercle that aids the plant in the acquirement of the free nitrogen, but the organisms for which the tubercle constitutes a home. The organism (*Bacillus radicicola* Beyerinck) which occupies the tubercle is generally considered to be a bacterium, although it contains some exceptional features of structure and development. The process by which these organisms find their conditions of growth in the host plant, and at the same time promote the growth of the host, has been called symbiosis.[2] The nature

[1] See G. F. Atkinson: Cont. Biol. Org. Causing Leguminous Tubercles; in Bot. Gaz. Vol. XVIII, pp. 157, 226, 257.

[2] The Chinese word for this process means friendship.

of symbiosis is not well understood. That tubercles contain a high percentage of nitrogen is established. Whether the host plant secures its supply of nitrogen as a result of the life processes of the bacteria, or as a result of the death and decomposition of the bacteria, is not definitely known.

136. Acquirement of Nitrogen without Legumes.—Arable soils may gain nitrogen without the aid of legumes. If sterilized soil is allowed to stand without growing any plants, the nitrogen content will not increase; but if unsterilized soil in good tilth is allowed to stand, the nitrogen content may increase.

A considerable number of bacterial species in the soil possess in a more or less marked degree the power of utilizing elementary nitrogen for their growth. There is some reason to suppose, even, that *Bacillus radicicola,* the organism which leads to the formation of tubercles on the roots of legumes, may grow in the soil outside of the legume tubercles, and cause there the fixation of slight amounts of nitrogen. Of the soil organisms known to possess the ability to fix atmospheric nitrogen, there are two distinct groups that are particularly prominent. The first of these groups is represented by *Clostridium pasteurianum,* an anaerobic butyric ferment isolated and described by Winogradsky.[1] The second group is represented by the Azotobacter species, particularly *Azotobacter chroococcum* Beyerinck[2] and *A. vinelandii* Lipman and *A. beyerincki* Lipman.[3] The exact significance of these organisms in the economy of soil nitrogen is still to be determined. Some of the recorded data show that cultivated soils may at times gain very considerable quantities of combined nitrogen without the intervention of legumes. Thus Kühn[4] was able to grow non-leguminous crops on the same land for 20 years without a

[1] Compt. rend. 1894, 118, p. 353.
[2] Centr. f. Bakt. Vol. VII (1901), Part II, p. 561.
[3] New Jersey Sta. Rpts., 1903, 1904, 1905.
[4] Centr. f. Bakt., Vol. VI (1901), Part II, p. 601.

diminution in yield, even though non-nitrogenous fertilizers alone were used. Hall[1] found an annual gain of 25 pounds of nitrogen per acre on Geescroft field, for the period 1882 to 1904, and that notwithstanding the fact that this field bore no leguminous vegetation.

137. Dissemination of the Bacteria by Natural Means.—The bacteria found in the tubercles of each genus, and, perhaps, of each species of leguminous plants, differ in some ways from those found on others. The various bacteria are generally regarded to be so closely allied that forms on one species of legume may adapt themselves to other closely allied species and genera. It is held to be probable that the time required for one form to adapt itself to an unaccustomed host depends somewhat on the degree of relationship between the respective host plants. It has been found in practise that closely related species of legume when following each other bear tubercles freely without any inoculation of the soil; that distantly related species the first year of planting on new ground do not generally bear tubercles freely the first year, but do so generally the second or third year when the sowing is repeated on the same ground.

The New York State Station has determined that these organisms usually die within a few days when dried under the usual atmospheric conditions.[2] The inoculation of one plat of ground from an adjacent plat has not been found to occur commonly, except through the washing of soil from one plat to another. Much more extended and accurate observations are necessary in order to determine the means and conditions under which the organisms are disseminated.

"Not every leguminous plant requires artificial inoculation in order to produce tubercles. Many soils are naturally supplied with the tubercle-producing germs through the growth of wild leguminous plants. Moreover, where

[1] Journal Agr. Science I, May, 1905.

[2] New York State Sta. Bul. No. 270 (1905), p. 382.

a given legume is extensively grown there is probably a wholesale inoculation of surrounding soils by means of the wind, which carries the germ-laden dust. This seems to be the explanation of the fact that on no soil has the writer been able to find cowpeas free from tubercles, and many observations have been made, all in localities where the culture of this plant is general. The seed of certain legumes may also be the means of conveying the necessary germs to a soil lacking the appropriate form of germ life. This seems to be the true explanation of the fact that lespedeza (and bur clover from unhulled seed) have developed tubercles in all soils where we have thus far tested them. Seeds of both these plants are borne in close contact with the ground where particles of the germ-laden soil easily lodge upon the burs or seed coats.

"Even though few or no tubercles may be produced the first year where a rare legume is grown for the first time, there is an increase in the number of tubercles from year to year if the same legume continues to occupy the land. Hence we should not look upon inoculation as needing to be repeated, but as a procedure useful only or chiefly in the first year's growth of a rare legume."[1]

Poor, thin soils deficient in humus and lime may make it worth while to use inoculation materials even for legumes that are not rare.

138. Need of Inoculation.—In the case of certain legumes, notably alfalfa and soy beans, it has been abundantly demonstrated that by placing 100 pounds or more of soil from a field which had the previous year grown tubercle-bearing plants of the same species upon each acre to be sown with the legume in question, the frequency of tubercles upon plants is increased thereby and the vigor of the plant is enhanced. (209)

When leguminous plants are grown in sterilized soil to which no organisms are allowed entrance the plants do not develop tubercles; but if a pure culture of the proper organism is added, tubercles will develop abundantly, assuming other conditions to be suitable. Further, if certain legumes, notably alfalfa and soy beans, are grown in soil which has not previously grown them, although the soil may have grown distantly related legumes, in many instances the plants will either not develop tubercles or will develop them sparingly; while if the proper

[1] Alabama Sta. Bul. No. 87 (1897), pp. 482, 483.

organisms are added to the soil in sufficient quantity, tubercles will form in abundance. It is, therefore, recognized to be good farm practise to supply the proper organisms when certain legumes are introduced upon the farm for the first time. The West Virginia Station has shown that there were present in the soil from what was once an old garden bacteria that could, without the use of artificial cultures, produce tubercles on 10 genera of legume representing 14 different species. In this soil soy beans failed to produce tubercules.[1]

It has been held that it is possible, by artificial means, to grow organisms that would have a greater vitality than organisms of the same kind native in the soil, and that in conformity with this idea it would be desirable to add these organisms to a soil already containing similar organisms. For example, it is held that it would be desirable to add to soil already growing clover these artificially grown and more virulent organisms in order to get a more vigorous growth of clover. Experiments by Hiltner and others indicate that this is possible.

139. Methods of Inoculation.—There are three methods of securing the inoculation of leguminous plants:

1. The continued growing of the same species of plant until the organisms already in the soil adapt themselves to the host, or until the few organisms of the proper form or function, which may unintentionally have been applied, multiply and produce the requisite abundance of tubercles.

2. The adding of artificial and more or less pure cultures of the proper form of the organisms. The organisms are readily grown, but the difficulty is with an economic and effective method of distribution. Attempts were made to distribute in tin foil pieces of cotton which had been dipped in a solution containing the organisms and then dried. When these organisms are dried quickly in a dry atmosphere they will retain

[1] West Virginia Sta. Bul. No. 105 (1906), p. 327.

their vitality for a considerable time. It was found, however, that when the organisms were dried slowly under the usual atmospheric conditions, as was done in commercial practise, the organisms were killed.[1]

3. To apply soil from a field that has produced abundantly tubercle-bearing plants of the species it is desired to grow. This is a successful method of inoculation. Soil at the rate of 100 or more pounds to the acre is spread upon the field after it is plowed and within a few days of planting. It is immediately harrowed into the soil in order not to subject the organisms to sunlight and air-drying. The soil should be obtained from the field in as fresh condition as possible. While being held for use it should be kept out of the sunlight and where it will not dry out. While this method has given excellent and fairly uniform results, so far as inoculation is concerned, it is rather expensive where soil is shipped long distances, and has the added disadvantage of possibly introducing weeds, fungous diseases and insect enemies. The New Jersey Station has obtained good results by passing water through an inoculated soil and sprinkling the water upon the land it is desired to inoculate.

140. Nitrifying and Denitrifying Organisms.—The sources of organic nitrogen in the soil are: (1) the nitrogen compounds

[1] The Department of Agriculture at Washington is now experimenting with a method of distributing liquid cultures in glass tubes, thus obviating the drying and consequent destruction of the organisms.

The liquid cultures are forwarded in hermetically sealed tubes accompanied by detailed instructions for multiplying and applying the bacteria. In one gallon of clean, boiled, and cooled water dissolve three teaspoonfuls of sugar and the contents of package No. 1 (which consists of 72 grains of potassium phosphate, monobasic, and three grains of magnesium sulphate). Add the cultures, package No. 2, and keep in a warm place. After 24 hours add package No. 3 (which contains 0.6 ounce of ammonium phosphate) and allow to stand for another 24 hours, when the liquid should be cloudy on account of the myriads of bacteria it contains. It is now ready for use. Moisten the seed with this liquid; dry, and sow as quickly as practicable. If preferred, the liquid may be sprinkled on a portion of soil and this scattered over the land.

formed by the joint activities of *Bacillus radicicola* and leguminous plants; (2) aerobic and anaerobic nitrogen-fixing bacteria living in the soil itself; (3) higher plants which transform nitrate or ammonia nitrogen, whether derived from fertilizer or soil sources, into organic nitrogen; and, (4) a great variety of soil bacteria which convert nitrate or ammonia nitrogen into protein substances. This organic nitrogen is made available as plant food through a process known as nitrification.[1]

The steps are held generally to be two. First, the organic nitrogen is changed into nitrous acid (HNO_2), which, combining with calcium or some other base in the soil, forms nitrites. These nitrites are then changed into nitric acid (HNO_3), which in like manner to nitrous acid is transformed into nitrates—the form in which nitrogen is believed to be absorbed by plants. This process is attributed to the action of bacteria. The first form has been given the name of nitrosomonas, and the second form the name of nitrobacter by Winogradsky, who has grown pure cultures of each. Under certain soil conditions—such as a lack of proper aeration of the soil—either the organic nitrogen or the nitrates of the soil may be decomposed and the nitrogen set free. This process is attributed to denitrifying organisms. Skilful agriculture, therefore, requires that soil conditions shall be provided which will assist nitrification at the proper time, prevent it at other times, and prevent denitrification at all times.

141. Effect of Lime on Legumes.—It has been abundantly proved that with certain soils under certain conditions the addition of lime may greatly increase the growth of certain leguminous crops. This has been shown to be true for clover at the Ohio Station and for alfalfa at the Cornell Station. It has long been held that lime assists the nitrification of organic

[1] The term nitrification should be restricted to the process by which organic nitrogen is changed into nitric acid, and should not be applied to the process by which the free nitrogen of the air is assimilated by plants.

matter by reason of furnishing a base for the nitrous and nitric acids formed, thus preventing the soil from becoming too acid for the proper growth of the nitrifying organisms. The Cornell Station found that not only was the size of the alfalfa plants greatly increased where lime was added, but that the water soluble nitrates were also greatly increased.

Assuming that an increase in water soluble nitrogen is the cause of the increase in the growth of alfalfa—which is highly probable, although not yet, perhaps, fully demonstrated—the observations above reported may be taken as indicating that lime does assist in nitrification; or, since it has been demonstrated that legumes excrete organic nitrogen into the soil, it may be assumed that the lime furnishes the proper conditions for the vigorous development of the tubercle-bacteria, and thus the increase in the water soluble nitrogen is a result and not the cause of the increased growth of alfalfa. Whichever may be the fact, the lime asists the legume in some manner to get in a comparatively short time an abundant supply of nitrogen.

142. Value.—Leguminous plants are of vast importance to agriculture and hence to mankind. The different ways in which they are valuable, especially the leguminous forage crops, may be enumerated as follows:

1. They help to balance the food ration of man and of domestic animals. The great bulk of agricultural productions, either in grain or roughage, is from plants belonging to the grass family. The latter produce an abundance of starch and other heat-forming substances, but are relatively deficient in protein or muscle-forming foods. The leguminous crops produce in the whole plant, as well as in the seed, a large percentage of protein; hence they tend to correct, when used, the otherwise one-sided ration. It is desirable to feed growing cattle clover, alfalfa, or cowpea hay with the grain or stover of maize, for the same reasons that human beings eat meat with potatoes. Too much clover hay or too much meat would be undesirable.

The table following gives the average of American analyses for the more common leguminous forage and grain crops. The analyses of timothy hay and of maize grain are given for comparison.

Analyses of Leguminous Plants

Name of plant	Number of analyses	Water	Ash	Protein Nx 6.25	Crude fiber	Nitrogen-free extract	Fat
Forage		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Timothy	68	13.2	4.4	5.9	29.0	45.0	2.5
Alfalfa	21	8.4	7.4	14.3	25.0	42.7	2.2
Alsike clover	9	9.7	8.3	12.8	25.6	40.7	2.9
Bur clover	..	8.9	5.0	13.7	30.6	38.2	3.6
Crimson clover	2	8.0	8.4	15.6	32.0	34.3	1.7
Mammoth clover	4	26.3	5.8	10.2	22.4	30.4	4.9
Red clover	38	15.3	6.2	12.3	24.8	38.1	3.3
Sweet clover	..	[1] ...	7.7	17.2	34.0	38.2	2.9
White clover	7	9.7	8.3	15.7	24.1	39.3	2.9
Hairy vetch	..	11.9	5.8	23.0	19.7	36.6	3.0
Kidney vetch	..	[1] ...	13.3	18.4	14.9	48.9	3.5
Spring vetch	..	11.1	7.1	16.0	26.1	37.3	2.4
Soy bean	..	6.5	7.9	14.1	20.4	45.2	5.9
Velvet bean	..	[1] ...	7.2	14.8	40.3	36.4	1.3
Cowpea	8	10.7	7.5	16.6	20.1	42.2	2.9
Japan clover	..	9.1	4.1	13.7	21.6	47.5	4.0
Field pea	..	[1] ...	11.3	26.7	18.1	40.7	3.2
Grain							
Maize	208	10.9	1.5	10.5	2.1	69.6	5.4
Field bean	..	15.0	3.1	20.4	3.2	56.7	1.6
Soy bean	8	10.8	4.7	34.0	4.8	28.8	16.9
Cowpea	5	14.8	3.2	20.8	4.1	55.7	1.4
Peanut	11 [2]	7.8	2.6	27.2	3.9	13.2	45.3

[1] Water-free substance.

[2] This average includes 6 foreign analyses.

2. A ton of clover, alfalfa, or cowpea hay contains more nitrogen than does a ton of timothy hay, maize fodder, or a ton of the grain of maize or oats. Nitrogen being the most expensive of the commercial fertilizing elements, manure produced from legumes is correspondingly more valuable than that produced from foods of the grass family. The table following shows the percentages of the essential fertilizer ingredients in legumes as compared with timothy hay, wheat straw, and maize grain.

Table Showing Fertilizer Ingredients

Name of plant	Ash	Nitrogen	Phosphoric acid	Potash
Forage				
Timothy	4.93	1.26	.53	.90
Red clover	6.93	2.07	.38	2.20
Crimson clover . . .	7.70	2.05	.40	1.31
Alsike clover	11.11	2.34	.67	2.23
Alfalfa	7.07	2.19	.51	1.68
Soy bean (whole plant) . .	6.47	2.32	.67	1.08
Cowpea (whole plant) . .	8.40	1.95	.52	1.47
Wheat straw	3.81	.59	.12	.51
Grain				
Maize grain	1.53	1.82	.70	.40
Soy beans	4.99	5.30	1.87	1.99
Field pea meal . . .	2.68	3.08	.82	.99
Peanut (kernels) . . .	3.20	4.51	1.24	1.27

3. Generally speaking, leguminous crops leave in and on the soil a larger quantity of vegetation than do the cereal crops. This organic matter contains a relatively larger quantity of nitrogen, phosphoric acid, and potash which become available to the plant with the decay of the vegetation. The land is thus in a more suitable condition to grow a succeeding crop, particularly a cereal crop, than if the leguminous crop had not

been grown. Grass crops also leave a considerable quantity of vegetation behind them, sometimes a greater quantity than red clover, for example, but usually it is not so rich in nitrogen, phosphorus, and potassium.

The deeper root habits of most leguminous plants not only make it possible for them to make use of fertility at lower depths but thus, possibly by leaving these elements near the surface, to make them available to shallower rooted plants. This, however, has not been demonstrated experimentally, and a critical study of the root habits of leguminous plants leads to the belief that this quality in them has been overestimated. (147)

4. The so-called virgin fertility of a soil is largely due to the nitrogen combined in organic matter. While this fertility has, doubtless in many instances, been collecting through countless ages, yet due to denitrification and the leaching of nitrates, the balance of available nitrogen at any time is not large, and by certain systems of cropping it can be easily brought to such a point as to make the soil unproductive. On the other hand, the necessary available nitrogen can be readily, although not necessarily, economically restored.[1] Leguminous forage crops furnish the agency through which the necessary available nitrogen may be in a measure maintained, and frequently are the most economical means of doing it, since they are capable of securing their nitrogen supply from the free nitrogen which constitutes four-fifths of the atmosphere. What proportion of the nitrogen found in the leguminous plants comes ordinarily from nitrates already in the soil, and what proportion comes from the free nitrogen of the air through the aid of tubercle-bacteria, has not been fully determined. The indications are

[1] The algebraic sum of the gains and losses of nitrogen which occur in all soils is a plus quantity in untilled soils and a minus quantity in soils constantly cultivated. In the latter case, however, the minus quantity may be converted into a plus quantity by proper methods of fertilization and crop rotation.

that the poorer the soil is in nitrates—and hence the greater the need of soil and plant for nitrogen—the greater the supply obtained from the atmosphere. (132)

5. The organic matter left in the soil improves the physical condition of most soils. Probably the most important physical property is that with reference to the retention and passage of water in the soil. The decay of deep-growing tap roots of red clover and alfalfa in the sub-soil may assist drainage materially by offering an opening for the passage of water. On the other hand, the decay of large amounts of vegetable matter in the surface soil enables the water to enter the soil more freely rather than running off the surface, and also enables the soil to hold the optimum amount of water. The influence which these factors may have on the time that must elapse before land can be cultivated after heavy rains, and on the number of days in the year that it is possible to cultivate the land is often extremely important.

6. The introduction of leguminous plants has offered opportunity for a better system of rotation—not alone for reasons just stated, but because it brought into the rotation a plant not subject to the same insect enemies and fungous diseases of cereals and grasses, and perhaps for other reasons not well understood. The introduction of red clover, together with root crops, resulting in the Norfolk system of rotation, revolutionized the agriculture of Great Britain and had a profound influence indirectly upon the colonists of North America. "Red clover has contributed even more to the progress of agriculture than the potato itself, and has had no inconsiderable influence on European civilization. Its cultivation has led to an increased production of stock as food for man, and in this way has fostered and advanced commerce, industry, and science."[1]

143. Collateral Reading.—H. W. Conn: Agricultural Bacteriology, pp. 76-108; 130-162. Philadelphia: P. Blakiston's Son & Co., 1901.

[1] Stebler and Schröter: The Best Forage Plants, p. 123.

A. D. Hall: The Soil, pp. 161-186. New York: E. P. Dutton & Co., 1904.

A. D. Hall: The Book of the Rothamsted Experiments, pp. 1-14; 217-239. London: John Murray, 1905.

Jared G. Smith: Leguminous Forage Crops. In U. S. Dept. Agr. Yearbook 1897, pp. 487-492.

G. T. Moore: Soil Inoculation for Legumes. U. S. Dept. Agr., Bureau of Plant Industry Bul. No. 71 (1905), p. 72.

K. F. Kellerman and T. R. Robinson: Inoculation of Legumes. U. S. Dept. Agr., Farmers' Bul. No. 240, 1906.

H. Garman: Kentucky Forage Plants. Kentucky Station Bul. No. 98 (1902), pp. 4-13.

VIII

LEGUMINOUS FORAGE CROPS

I. CLOVERS

144. Relationships.—The genus *Trifolium* (clovers) is closely related to *Medicago* (alfalfa) and *Melilotus* (sweet clover) in that in all the leaf is divided into three leaflets. In the case of the clovers, however, the three leaflets arise from the end of the leaf stalk or petiole, *palmately lobed,* while in the other two genera the lateral leaflets arise from the sides of the petiole some distance from the end, *pinnately lobed.* The *Melilotus* is readily distinguished by its flowers being in racemes, while in the *Medicago* the coiled or curved or kidney-shaped pod serves to distinguish the species of this genus from the clovers.

145. Number and Distribution of Species.—The number of species belonging to the genus *Trifolium* is about 250, variously estimated from 150 to 290. They are most abundant in the North Temperate Zone. About 65 species are known in North America, the greatest number being found native to the Western states.

List of Clovers of Economic Importance [1]

Native

SPECIES GROWING IN THE EASTERN PART OF THE UNITED STATES

Buffalo clover, *Trifolium reflexum* L.
Running buffalo clover, *T. stoloniferum* Muhl.
Carolina clover, *T. carolinianum* Michx.
White clover, *T. repens* L.
Southern clover, *T. amphianthum* T. & G.

[1] Some of the species in this list are probably of no economic importance, but are included because they have been tested at one or more experiment stations.

SPECIES GROWING IN THE WESTERN PART OF THE UNITED STATES

T. begariense Morie
Mountain red clover, *T. megacephalum* Nutt.
T. eriocephalum Nutt.
Long-stalked clover, *T. longipes* Nutt.
Beckwith's clover, *T. beckwithii* Brewer
T. involucratum Willd.
T. tridentatum Lindl.
Lowland clover, *T. microcephalum* Pursh.
Western clover, *T. furcatum* Lindl.

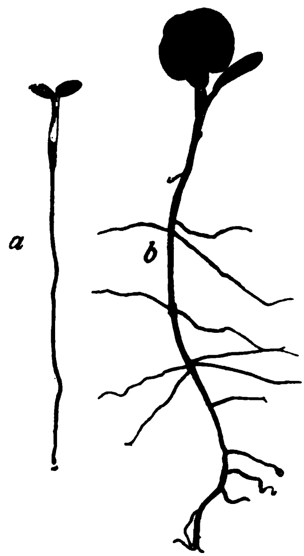
Introduced and Foreign Species

Golden clover: yellow hop-clover, *T. agrarium* L.
Low hop clover: lesser trefoil: yellow clover, *T. procumbens* L.
Least hop clover: trefoil, *T. dubium* Sibth.
Yellow suckling clover: slender clover, *T. filiforme* L.
Berseem: Egyptian clover: Alexandrian clover, *T. alexandrinum* L.
Rabbit-foot: Hare's-foot: Pussy: Oldfield: stone clover, *T. arvense* L.
Alsike or Swedish clover, *T. Hybridum* L.
Said to be smaller variety of alsike with white haired stems, *T. elegans* L.
Reversed clover, *T. resupinatum* L.
Strawberry-headed clover: strawberry clover, *T. fragiferum* L.
Knotted clover: soft knotted trefoil, *T. striatum* L.
Crimson clover: scarlet clover, *T. incarnatum* L.
Red clover, *T. pratense* L.
Mammoth clover, *T. pratense perenne* Hort.
Zigzag clover, *T. medium* L.
Hungarian clover, *T. pannonicum* Jacq.

II. RED CLOVER

146. Name.—Red clover (*Trifolium pratense* L.) is also known as common clover, June clover, meadow clover, broad-leafed clover, and meadow trefoil. It is also known as medium clover or medium red clover to distinguish it from its cultivated variety, mammoth clover or mammoth red clover.

147. Roots.—The tap roots which may be forked into two or more branches have been found extending six or more feet in the ground, but usually they do not extend beyond two feet. The secondary roots which are numerous usually arise from the upper third of the tap root and occupy the surface area of the soil. When the plants are subject to heaving, plants may be found with the tap root broken off near the surface of the earth. The tap root is doubtless an important factor in enabling the red clover to withstand drought, but probably the importance of red clover as an agent in bringing plant food from the sub-soil into the surface soil has been overestimated, since by far the largest root area is to be found in the surface soil.



Individual plants of red clover, showing root system: *a* one week from planting; *b* two weeks from planting

The roots of red clover have an interesting habit of shortening and thus drawing the crown of the plant down into the soil. "This change protects the lower buds from the scythe, gives the plant a firmer hold of the ground, and prevents uprooting during winter."[1] Under greenhouse conditions this occurs in six to eight weeks after sprouting. Under like conditions tubercles appear upon the main root in two weeks and upon branches in four weeks.[2] The tubercles, at first spherical and later becoming pear-shaped and sometimes compounded into clusters, are about one-tenth of an inch in length with one-third to one-half that diameter.

148. Habit of Growth above Ground.—The primary stem always remains short and never flowers, but bears a rosette of leaves by reason of the short internodes. From the axils of

[1] Stebler and Schröter: The Best Forage Plants, p. 127.

[2] Laura Gano: The True Clovers; thesis, Master of Science in Agriculture, Cornell University, p. 147, 1906.

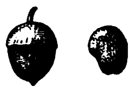
these leaves arise commonly 8 to 10, sometimes 15 to 20, more or less erect leafy branches, with a flower head at their apex. These branches may branch and re-branch, each branch terminating in a flower head and thus making a bushy, leafy plant with a large proportion of leaves and small stems. Dietrich gives the relative proportion of parts when in full bloom as: leaflets 19, leaf-stalks 11, heads 11, and stems 59 per cent.

The height and erectness of the stems depend upon the nature of the soil, the usual height under proper cultural conditions varying from 18 to 30 inches. In case the stems become procumbent, the lowest nodes—usually not more than two—produce roots, thus giving red clover a slightly creeping habit. Compared with alsike, white clover, or alfalfa, the leaflets are large, 1.25 to 2 inches long; 0.75 to 1 inch wide, and variable in form, and possess more or less prominent v-shaped white markings. The leaf-stalk varies from one to six or more inches in length.

All the vegetative portions are covered with a hairy down quite variable in amount under different conditions of growth—the younger the growth, the thicker and more prominent the hairs. The younger parts are also tender and succulent while the older portions become woody with a pithy interior. When the stems are cut, the remaining portion dies except the short bud-bearing internodes at the base, which soon develop and form new branches. When cut for seed, the whole stem usually dies. The stipules, one inch in length and attached to the petiole, have prominent parallel veins. The free triangular apex is prolonged into an awn-like process.

149. Inflorescence.—The inflorescence consists of round to elongated oval, single, sometimes forked spikes, typically one to one and a half inches long, containing from 100 to 200 dark to light pink, sometimes white, sessile flowers. The first crop of red clover blooms throughout the North Atlantic and North

Central states during June, and the second crop during August. The flowers bloom progressively from the lower to the upper parts of the head, and for a single head occupy four to ten days. Hopkins estimates that a field will remain in bloom from 15 to 30 days during the second crop. The stage of full bloom is therefore a rather uncertain point.



Red clover capsule on the left; single seed on the right. Enlarged four times.

When the flowers dry they easily break off by reason of their brittle pedicel, but the calyx and the withered corolla are persistent. In damp weather these absorb moisture and become spongy, making threshing or hulling quite difficult. The pod is a one-seeded capsule and differs from that of other clovers or other leguminous plants in that it is not a legume but is orbicular, opening transversely, thus dividing the pod into an upper smooth, shiny, thin-walled cap and a lower small thin-walled box which readily tears and allows the seed to escape.

150. Description of Seed.—Viewed in outline from its two longest diameters the seed is oval, with the raphe or radicle forming a distinct projection. Viewed from its two smallest diameters the seed is flattened. Sizes vary greatly: the average length is 0.07 inch; width 0.05 to 0.06 inch; thickness 0.03 to 0.04 inch. The average number of seeds to the pound is about 375,000, from which there may be a variation of 50 per cent. either way. The legal weight of a bushel in nearly all states and Canada is 60 pounds.

The seeds may be uniformly yellow, or uniformly purple, or variegated with yellow, lavender, or violet and purple. Unripe seeds are yellowish green. With age the color is said to change to drab, afterward passing into red. The dark seeds, which are probably the more thoroughly ripened, are likely to be "hard" or dormant.

151. Impurities and Adulterations.—Red clover is now rarely adulterated. In Europe colored grains of sandstone were not uncommonly used. Large quantities of black medic or yellow trefoil seeds have been imported into this country in recent years and have been mixed with red clover and alfalfa—

Red clover seed and a few of its impurities: *a* Dodder (*Cuscuta arvensis*); *b* black medic (*Medicago lupulina*); *c* red clover (*trifolium pratense*); *d* broad-leaved plantain (*Plantago rugelii*); *e* rib-grass (*Plantago lanceolota*). Much enlarged (after Pieters).

probably more commonly with the latter. (236) The seeds of sweet clover sometimes, although rarely, occur. (250) The mixture of other but useful seeds—such as timothy and alsike clover—is not uncommon. This is frequently due to the crops growing together, but they may also be artificially mixed on account of the lower cost of the seed.

The Delaware Station found the average of the pure seed in samples examined to be 93 per cent., with no sample below 90 per cent.[1] Of 28 samples examined by the Ohio Station, only one was below 93 per cent.[2] The standard of purity should not be less than 98 per cent. The seeds occurring most frequently and in greatest number in clover seed were found by the Nevada,[3] Ohio,[2] and the Iowa[4] stations, in 70, 28, and 255 samples respectively, to be as follows:

Rugel's plantain, *Plantago rugelii* Decne
Rib-grass, *P. lanceolata* L.
Large bracted plantain, *P. aristata* Michx.
Lady's thumb, *Polygonum persicaria* L.

[1] Delaware Sta. Bul. No. 5 (1899).
[2] Ohio Sta. Bul. No. 142 (1903).
[3] Nevada Sta. Bul. No. 47 (1900).
[4] Iowa Sta. Bul. No. 88 (1907), p. 27.

Timothy, *Phleum pratense* L.
Bitter dock, *Rumex obtusifolia* L.
Curled dock, *R. crispus* L.
Sheep sorrel, *R. acetosella* L.
Fox tail grass, *Chaetochloa verticillata* (L.) Scribn.
Yellow fox tail, *Ch. glauca* (L.) Scribn.
Green fox tail, *Ch. viridis* (L.) Scribn.
Ragweed, *Ambrosia artemisiaefolia* L.
Lamb's quarters, *Chenopodium album* L.
Witch grass, *Panicum capillare* L.
Crab-grass, *P. sanguinale* L.
Rough pigweed, *Amaranthus retroflexus* L.
Tumbleweed, *Am. graecizans* L.
Alsike clover, *Trifolium hybridum* L.
White clover, *T. repens* L.
Selfheal, *Prunella vulgaris* L.

Along with these should be mentioned black medic and Canada thistle, the latter being reported by the Canadian Department of Agriculture to have been found in 23 per cent. of 163 samples.

152. Germination and Viability.—Haberlandt gives the temperature for the germination of red clover as follows: minimum 34°, optimum 86°, and maximum 99° F. With the optimum temperature and moisture seeds will begin to sprout vigorously in two to four days. The standard of germination is 90 per cent. The Ohio Station found a range of 32 to 99 per cent. of germination in 28 samples of commercial seed.[1] The New York State Station found the highest germination when the specific gravity was between 1.25 and 1.30, and less when either above or below this specific gravity.[2]

The viability of clover seed has not been definitely determined, but with our present knowledge seed that is over three years old must not be considered safe to sow. Beal found an average germination of 36 per cent. in red clover seed that had

[1] Ohio Sta. Bul. No. 142 (1903).
[2] New York State Sta. Bul. No. 256 (1904).

been kept with care in corked bottles for twelve years.[1] Red clover seed is not greatly subject to injury during storing from vermin or insect enemies, and consequently is deemed by some a desirable article to buy and store when prices are low.

153. Varieties.—Aside from mammoth clover there are no recognized varieties of red clover cultivated in America. (177) Red clover sometimes has white flowers when it has been referred to as a distinct variety, but it is not cultivated as such.[2] Red clover seed obtained from various American and European sources has been tested at different stations. At the Maine Station plants from American and south European seeds respectively were the first to mature and gave the largest yields. The second year's growth demonstrated the superior hardiness and vigor of plants from American grown seed.[3] The stems and leaves of the plants grown from European seed were characterized by the lack of hairiness, which was taken as an explanation of the greater cleanliness of European clover hay as compared with hay from American clover seed. Seed of this type of clover has been introduced into America from the "Black Earth" region, in the eastern part of the Orel government of Russia, under the name of hairless Orel clover. In addition to the dustlessness of its hay, this plant is said to be more erect, leafier, more palatable, and to mature ten days or two weeks earlier than the ordinary American red clover.[4] The North Dakota Station found the plants from American grown seed to be superior to plants from foreign seeds, the chief difference being in the production of plump and valuable seed.

On the other hand, the German Agricultural Society tested seeds from 15 different sources, and after two years it was found

[1] Soc. Prom. Agr. Sci., 1894.
[2] Buckman: Science and Practise of Farm Cultivation.
[3] Maine Sta. Bul. No. 113 (1905), pp. 28-36.
[4] U. S. Dept. Agr., Bu. Pl. Ind. Bul. No. 95 (1906).

that German seed was superior, with Pennsylvania and Missouri seed ranking fourth and eleventh respectively; while at Kiel, Germany, in a similar experiment, Burchard found that clover from American seed stood the winter most satisfactorily and gave the largest yields. Nielsen in Denmark found at the end of two seasons that average yields of red clover hay gave Danish seed second rank with 98 per cent., and American seed third rank with 95 per cent. Seed of red clover from Chile has been introduced into Canada with good results.

154. Distribution.—Red clover is widely diffused through Europe. It is successfully cultivated throughout the United States and Canada east of the one hundredth meridian and north of the Gulf states. In the region of the Great Lakes it is replaced somewhat by alsike clover and in some places, especially in certain limestone areas, it is replaced by alfalfa. With these exceptions red clover and its variety, mammoth clover, are cultivated for hay throughout the region named, almost to the exclusion of any other leguminous forage plant. It is also cultivated along the Pacific coast north of California.

155. Duration.—The plant is described by some as a biennial and by others as a perennial of a few years' duration. The plant varies considerably in this and other respects in different localities. Assuming favorable conditions, it is usual when timothy and clover are sown together for the first crop to be largely clover, the second year (third from seed) about half and half timothy and clover, and the third year largely if not quite wholly timothy. If timothy is sown with the fall grain, it is somewhat more predominant from the first.

156. Adaptation.—Red clover is adapted to a temperate climate. It will not stand as much cold and moisture as alsike clover, nor as much heat and drought as alfalfa. It grows on soils of all states of fertility except the poorest. The fertility of the soil may be correctly ascertained by the appearance of the clover plant, assuming a proper quantity of rainfall. It is not entirely hardy throughout the North Atlantic and North Central states. It is not infrequently killed by being heaved out in winter or spring months, especially on poorly drained land. It is not well adapted to stiff clay soils as timothy and other grasses are. It is best adapted to well-drained loams, especially those derived from limestone. While perhaps the yield is less upon sandy loams than upon clay loams, there is less danger from winter killing. A plentiful supply of organic matter in the soil is desirable for red clover. It is better adapted to so-called maize lands than to wheat lands. (C. A. 115)

157. Fertilizers.—Soils that formerly grew clover, but upon which its cultivation has become difficult, can usually be restored by the application of stable manure and lime. The stable manure makes it possible to secure a stand by reason of the organic matter furnishing the proper moisture conditions during germination and early growth, and the lime furnishes proper conditions for an abundant growth of bacteria-bearing tubercles. Where a suitable rotation is practised, the stable manure and lime may best be applied to the maize crop rather than to the wheat or oat crop in which the clover is seeded. (C. A. 292) Gypsum or sulphate of lime at the rate of 500 pounds to the acre, applied directly to the clover crop during April or May, sometimes may be used with good results on lands containing plenty of organic matter.

Potash fertilizers and, on soils relatively low in phosphates, phosphoric fertilizers favor the growth of clovers. Wood ashes containing both lime and potash are frequently used with good results. In mixed herbage the influence of wood ashes in increasing the growth of clover is so marked that it has given rise to the saying that wood ashes contain clover seed.

"It appears, therefore, that, on the soil under experiment, the presence of an abundant supply of available lime, together with phosphorus and potassium, has enabled the clover plant to make a normal growth without the assistance of any nitrogenous fertilizer; but that, in the absence of lime, the clover must be supplied with combined nitrogen, and that in large quantity, as well as with phosphorus and potassium." [1]

158. Seeding.—While red clover may be sown at any time during the growing season, the best results will usually be obtained by sowing in early spring. Good judgment is required as to the exact time of sowing. Much depends on the season. The young plants may be killed by a sharp freeze or by a dry spell of a few days' duration, particularly if the seeds have not been well covered. In general, drought is more to be feared than freezing, hence early sowing is usually advisable. For its best germination, red clover seed should receive a light covering of soil. Whether this will take place by natural means or can best be secured by harrowing or rolling will depend upon the soil, condition of the seed-bed, and the climatic conditions. Sowing on a late snow often gives good results. The seed sink into the liquid mud produced by the melting snow. Likewise, a sharp freeze that has produced a tessellated condition of soil is a desirable preparation, since the seeds fall between the crevices and the soil, subsequently thawing, covers them.

When seed is sown late on fall grain the ground may be harrowed immediately after seeding without injury to the grain and to the benefit of the clover. This is especially desirable on heavy clays and soils lacking in organic matter. On loamy soils and those high in organic matter rolling may be sufficient. With spring grain the seeding may be accomplished by means of the seeder attachment to the grain drill, which will deposit the seed either before or behind the drills, as the condition of the ground may indicate to be best. Seeding may be done after the grain has been sown, either with the hand seeder or the wheelbarrow seeder. Either machine may also be used in spring seeding of clover on autumn sown grain. (26)

[1] Ohio Sta. Bul. No. 159 (1905), p. 181.

159. Quantity of Seed.—The amount of seed to sow varies largely with the locality and the climatic conditions. The rainfall and the character of the soil in particular—especially the amount of organic matter—are probably the determinant factors. Ten pounds to the acre or nearly 85 seeds a square foot are about the average when sown alone; twice this quantity is said to be sown in some localities. When sown with timothy or other grass, six to eight pounds will usually suffice. The Canada Station found that when seeded with oats or barley 10 pounds produced the largest yield.

160. Weeds.—The list of seeds given in the paragraph above indicates the weeds which not uncommonly occur in clover fields, but does not necessarily indicate the most common or the most injurious weeds. The most common weed in both timothy and clover meadows is *Erigeron* Sp., and yet the seeds of this plant have not been reported as occurring in either clover or timothy seed. The small seeded dodder, of which there are two forms (*Cuscuta epithymum* Murr. and *C. trifolii* Bab.), and the large seeded or field dodder (*C. arvensis* Beyr.) occur on red clover, although more commonly on alfalfa—doubtless because the latter is perennial. (202) Since all forms of dodder are easily eradicated by putting the land in non-leguminous crops, it is not greatly to be feared in red clover. Broom-rape (*Orobanche minor* J. E. Smith), though quite a familiar plant in European countries, has been reported as being abundant and destructive only in New Jersey.[1]

161. Clover Sickness.—For a century it has been recognized in Europe to be difficult to raise clover in short rotations. At Rothamsted, England, it was found impossible to grow clover oftener than once in four years, while Stebler states that on some soils in Europe six and even nine to twelve years must elapse before a good crop can be secured. Though in America

[1] Torr. Bot. Club Bul. No. 25 (1898), pp. 395-7.

the complaint that land does not grow clover as readily as formerly is not uncommon, the necessity for a lapse of years between crops has not been clearly recognized. The causes for this condition are not understood. The causes which may be ascribed for the failure of clover are as follows: (1) fungous diseases; (2) insect enemies; (3) lack or exhaustion of one or more essential elements, particularly potash; (4) unfavorable physical properties of the soil and sub-soil, particularly the latter; (5) acidity of the soil; (6) lack of the tubercle-forming and nitrogen-gathering bacteria. It is probable that the causes mentioned have been operative at different times and places in preventing the growth of clover.

162. Fungous Diseases.—Gursow studied the "clover-sick" plants at Rothamsted in 1901 and identified a fungus (*Peziza ciboroides* Fries, *Sclerotinia ciboroides* Rehm.) which was sufficient to destroy the plant in the manner in which most of the clover was affected throughout the clover-sick region. This fungus has long been known to do considerable damage in northern Germany. Alfalfa, white clover, and other leguminous species are affected by it. Gursow states that in the earlier stages of the disease, when the dark spots first occur on the leaf, spraying with Bordeaux mixture would modify if not check the disease.[1]

In Tennessee, where the failure of red clover to grow has become pronounced, an anthracnose (*Colletotrichum trifolii* Bain) has been found attacking both red clover and alfalfa, but to which alsike clover appears to be immune. It is believed to be the most serious plant disease occurring in that state. While the plant may succumb to the disease at any time, the most critical periods appear to be when the seedlings encounter the first prolonged spells of summer and again when the plant ripens its seed.[2]

[1] Jour. Roy. Agr. Soc. Eng. No. 64 (1903), pp. 376-91.

[2] Journal of Mycology, 12 (Sept., 1906), pp. 192-3.

Among the numerous fungi attacking the clovers the following may be mentioned as being of more or less economic importance:

Powdery mildew, *Erysiphe polygoni* D. C.
Clover rust, *Uromyces trifolii* Hedw.
Downy mildew, *Peronospora trifoliorum* De Bary.
Leaf spot, *Phyllachora trifolii* (Pers.) Fckl.
Root fungus, *Rhizoctonia violacea* Tul.
Damping off, *Pythium debaryanum* Hesse.
Leaf spot, *Pseudopeziza trifolii* Bernh.
Stem rot, *Sclerotinia trifoliorum* Eriks.

163. Insect Enemies.—More than 80 insects in the United States and a much larger number in European countries are known to do more or less damage to red clover. Wire worms (C. A. 328), cutworms (C. A. 329), and white grubs (C. A. 330), being omnivorous feeders, may do serious injury to red clover, as may also blister beetles, locusts and leaf hoppers. None of them, however, can be considered specifically clover insects.

The most injurious insects confined to red clover and other closely allied legumes are:

The clover root borer, *Hylastes trifolii* Mull.
The clover leaf weevil, *Phytonomus punctatus* Fab.
The clover seed midge, *Cecidomyia leguminicola* Lint.

The clover root borer is a small brown or black beetle one-eighth inch long, which lays its eggs in the crown of the plants in spring. These hatch in about a week, and the larvae burrow into and destroy the roots. The larvae must find sustenance in the plant or perish. If, therefore, the clover is plowed before the larvae are old enough to pupate—say between June 15 and July 1, immediately after cutting the first crop—they will be destroyed. In some sections a crop of buckwheat could be obtained. The beetle is single brooded.

The clover leaf weevil is a large brownish and yellowish snout beetle 0.04 inch long. Adults and larvae feed upon the leaves of clover, the larvae mostly in May and the beetles in July and August. A second brood of larvae appears in September: they pupate in October, emerge as beetles in November, and hibernate when quite small within the clover stem. Aside from a rotation of crops there is no practicable remedy. Fortunately, however, it is subject to a fungous disease (*Entomophthora sphaerosperma* Fresn.) which is effective in holding it in check.

The clover midge, which is closely allied to the Hessian fly (C. A. 152), lays its eggs in the flower heads. The eggs hatch into yellow or orange maggots and later do damage by living within the developing seeds. There are sometimes two broods produced in a season. Early cutting of the first crop is recommended.

164. Harvesting Hay.—Red clover produces two crops annually. The second crop is quite variable, depending on the season, the rainfall being the controlling element. Since frequently the second crop does not pay for cutting, it is desirable to be able to pasture the aftermath of clover meadows. In some localities the second crop is considered with disfavor, except as a seed crop; in others it is used with good results. Probably the second crop is usually cut when too ripe, reducing both palatability and digestibility, and by reason of the contained seed causing "slobbers" or other unfavorable effects.

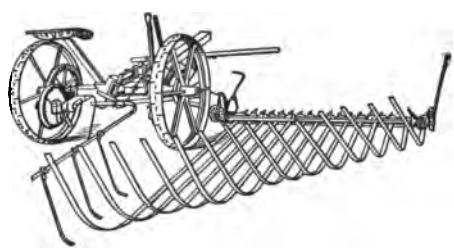
At the Illinois, Pennsylvania, and Connecticut stations, the largest yields of dry matter and protein were obtained when the heads were in full bloom or just past that stage. There was a material increase in crude fiber as the plant ripened.[1] From all the evidence at hand, the best time to cut red clover appears to be when about one-third the heads have *begun* to turn brown. (36)

Clover is more difficult to cure than timothy or the grasses generally, because (1) in the first crop as favorable weather for curing does not exist; (2) the plant is more succulent, contains a higher percentage of water; (3) when placed in piles it absorbs the rain more readily; and (4) the leaflets and flower heads are more easily broken off in handling than the leaf blades and spikelets of grasses. Moreover, clover hay is more likely to become dusty when rained upon or when improperly cured than in the case of grasses. The greatest care and skill, therefore, are required to cure clover properly. (37) No

[1] Illinois Sta. Bul. No. 5 (1889).

specific directions for curing clover can be laid down, but recognizing the character of the plant and the sources of deterioration as stated under 37, an attempt should be made to obtain the best possible product at the least cost.

165. Harvesting Seed.—The most abundant seed is obtained from plants that do not grow so large as to be blown down or become decumbent on account of their great weight. Thin dry soil is therefore most suitable to a seed crop. Throughout the North Atlantic and North Central states only the second crop is cut for seed, since the first crop seeds less abundantly than the second. Two reasons for this have been offered. First, since the second crop is not so luxuriant as the first, it is less likely to fall down from wind or otherwise; and second, the first crop is usually harvested before bumblebees become abundant. The writer once had a late blooming first crop carefully examined, bumblebees having by that time become common, and found an abundance of seed.



G Mowing-machine with windrowing attachment; may also be used as a buncher when harvesting clover or alfalfa for seed

The crop should be cut when the flower heads are in the main brown or black and the seeds mostly hard. There will usually be some late flowering heads that will contain soft or leathery seeds. If harvested too early the seeds are likely to be immature and the yield small. If allowed to stand too long, new shoots will be thrown up bearing fresh flowers, which will retard the drying and interfere with the hulling.

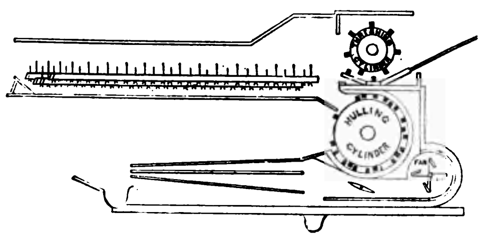
The crop may be cut with an ordinary mowing-machine and afterward put in bunches with barley forks, or when damp with spring tooth hay rake. Attachments to mowing-machines known as clover bunchers are now made and commonly used. The self-rake reaping machine is also used. (C. A. 163) With the latter the clover can be cut higher, making less material to handle and leaving a great stubble, and hence more organic matter to be plowed under. The clover buncher is less expensive and when clover is down may secure more seed. The clover is dried in small piles and where the weather is moist must be turned to keep seed from sprouting. On account of the ease with which flowers break off, the less the clover is handled the less the loss of seed. On the other hand, the alternate wetting and drying facilitates the hulling. From three to five days are required to cure for hulling, but two or more weeks may be allowed without material injury under suitable weather conditions. The quantity of seed varies greatly. Frequently only half a bushel, ordinarily two to five bushels, occasionally eight to ten bushels are obtained.

166. Clover Hullers.—Clover hullers differ from threshing machines in having an additional cylinder for hulling the clover seed and in the adjustment of the devices for cleaning the seed.

Sectional view of clover huller. Threshing cylinder above; hulling cylinder below, covered with hardened steel rasp

The clover first passes an ordinary threshing cylinder, which removes the heads from the stems and to a small extent hulls the seeds. The stems pass to the stacker while the heads, hulled seed, and chaff pass through riddles and are conveyed to the hulling cylinder, which removes the seeds from the pods and surrounding flower parts, after which the seed is cleaned, recleaned and conveyed into bags.

The huller cylinder and its concaves may be fitted with teeth having a wide-fluted blade, or with steel brads driven into wood through holes in the steel covering, or may be covered with a corrugated steel rasp. The ordinary grain thresher may be used by substituting concaves containing an increased number of rows of special corrugated teeth and by using sieves suited to cleaning the clover seed. The purpose in each case is to get a large amount of rubbing surface in order to remove the seed from its spongy covering.



Diagrammatic view of portion of clover huller showing hulling cylinder with spikes

Hardened steel rasp for covering clover hulling cylinder

There are at least ten manufacturers of clover hullers in the United States. The size of the hulling cylinder varies from 28 to 42 inches in length. Machines are made with and without self-feeders; with web or wind stackers. The smaller sizes may be operated by horse power; the larger sizes are for steam power only. One hundred or more bushels of seed may be hulled in ten hours; 20 to 40 bushels are common.

167. Value.—Red clover is adapted for hay, which has, when well cured, a high feeding value for growing animals, especially sheep, and for milch cows. The nitrogenous character of the food is less needed by mature work animals, and is generally not advised for horses, because of its liability to be dusty. In the markets, therefore, hay containing clover, unless of fancy grade, usually sells for less than pure timothy hay. Red clover does not make dense sod, and does not stand pasturing as well as alsike or white clover, or the grasses. Moreover, clover when pastured while the dew is on is liable to cause the death of cattle through bloating.

Red clover has a greater value in restoring the fertility of the soil than alsike clover, probably because of the greater amount of organic matter left in and on the soil, and because of the greater depth of its tap root. On account of being suited to grow readily with grain crops and with grasses it is better adapted to a rotation of crops than alfalfa.

168. Fertilizing Constituents per Acre.—The Storrs Station found a crop of red clover in full bloom, yielding 4,900 pounds of dry matter per acre, to contain 138 pounds of nitrogen, 152 pounds of potash, and 32 pounds of phosphoric acid. The roots and stubble contained, in addition, 44 pounds of nitrogen, 32 pounds of potash and 13 pounds of phosphoric acid. A ton of rich stable manure may contain 10 pounds each of nitrogen and phosphoric acid, and 8 pounds of potash.[1]

169. Feeding Value Compared with Timothy.—The total amount of digestible nutrients in 100 pounds of clover hay is almost identical with that of 100 pounds of timothy hay. The Pennsylvania Station has shown that the fuel value—i.e., the total energy which can be set free in the body of a steer—is nearly the same with both kinds of hay. The net available energy, however, of clover hay when fed to a steer as a maintenance ration was found to be considerably less than that of timothy hay.[2] (12) On the other hand, clover hay furnishes more than three times as large a proportion of proteids as does timothy hay. The practical application of these experiments

[1] Storrs School Sta. Bul. No. 6 (1890), p. 14.

[2] Pennsylvania Sta. Bul. No. 71 (1905).

would seem to be that, for the purpose of balancing the ration, clover hay has a high feeding value for growing or milking ruminants; but where the ration already has sufficient protein for the needs of the animals, clover hay is not superior, and is perhaps inferior, to timothy hay in feeding value.

170. History.—Red clover was not known to the ancient Egyptians, Grecians, or Romans as a cultivated plant. It was first cultivated in Media, now Persia. It was introduced into Spain and Italy during the 15th and 16th centuries. During the latter century it was introduced from Spain into Brabant and Flanders. In 1633 it was introduced from Holland into England, and in about 1770 into Pennsylvania, probably from Germany.

III. MAMMOTH CLOVER

171. Characteristics.—Mammoth clover (*Trifolium pratense perenne* Hort.), known also as mammoth red clover, perennial red clover, sapling clover, and pea vine clover, frequently appears in American writings as *Trifolium medium* L. Zigzag or cow clover (*T. medium* L.) is an entirely distinct species and has never been known in commerce, probably on account of its poor seeding habit.

Mammoth clover is distinguished from red clover by its larger and coarser growth, and by its maturing from three to five weeks later. There are no constant and reliable characters by which the mammoth clover plant or seed can be distinguished from red clover. The chief differences are to be found in its more perennial character, its later maturity, and its larger and coarser growth. It produces but one crop each year, which seeds abundantly. This crop matures three to five weeks later than the first crop of red clover.

172. Advantages.—Mammoth clover matures about the same time as timothy. When red clover is sown with timothy the crop cannot be harvested when they are both in the best condition. The danger is that the crop will be harvested when the clover is too mature and before the timothy has reached the proper growth. Clover can generally be cured more readily in July than in June both on account of the greater heat and the drier atmosphere. The deep roots and coarse growth of mammoth clover give it a manurial value higher than that of red clover. The yield of seed is generally greater than with red clover. While one crop of mammoth clover may not yield as much as two crops of red clover, the larger single crop may be the more economical.

173. Disadvantages.—The coarse stems of mammoth clover are likely to become woody and produce hay which is less readily eaten by cattle than hay of red clover. This is especially true on rich soils where mammoth clover has a rather large proportion of stems to leaves. In this case the crop is likely to fall badly and the stems lying upon the ground are likely to deteriorate in quality before cutting.

174. Adaptation.—In general its soil and climatic adaptation and its cultural methods are similar to those of red clover. It is best adapted to relatively poor soils, both because of the greater benefit to the soil and because such soils prevent too rank a growth. On such soils it is an excellent crop to raise for seed, both because of the high yield of seed and the high manurial value resulting from the large amount of vegetable matter kept in and on the soil. This is especially desirable on farms where the live stock is not sufficient to consume it, should the clover be made into hay. Under these conditions an excellent rotation consists of maize, small grain, and mammoth clover, each one year. In some sections the small grain may be put in on the maize stubble without plowing (C. A. 128), and thus the land is plowed only once in the rotation. The clover may be pastured until June 1 with benefit to the crop of seed or may be clipped at this time with a mowing-machine. Either causes the plants to branch more freely and also to be shorter, and hence less liable to lodge.

175. Collateral Reading.—F. G. Stebler and C. Schröter: The Best Forage Plants, pp. 122-135. London: David Nutt, 1889.

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IX

LEGUMINOUS FORAGE CROPS

I. ALSIKE CLOVER

176. Relationships.—Alsike clover (*Trifolium hybridum* L.), also known as Swedish or hybrid clover, is a distinct species, although thought by Linnaeus to be a hybrid between white clover and red clover. Alsike clover is closely related to Carolina clover (*T. carolinianum* Michx.): the latter is much smaller. A smaller type of alsike clover (*T. elegans* L.) with solid stems downy near the apex and with doubly toothed leaflets is grown in Europe for ornamental purposes and to some extent for forage. In Europe, this type, when grown along with alsike, is said frequently to be the cause of disease among animals.

177. Description.—In appearance, especially of flowers and leaves, and in the smoothness and fresh green color of its vegetative parts alsike clover closely resembles white clover, while in habit of growth it resembles red clover. Alsike clover is rather more shallow and perhaps less abundantly rooted than red clover, although tap roots have been reported four feet deep. For this reason it has been held not to be as valuable a renovating crop. The roots, however, bear an abundance of tubercles of rather larger size than those of red clover. The plant branches less freely than red clover and is more likely to be decumbent when the lower two or three nodes root freely, thus giving it a creeping habit.

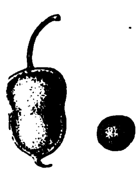
The flower heads are slightly larger than those of white clover and the flowers usually rather more pink. The corolla is about three times the length of the calyx while in white clover it is about twice the length of the calyx. The flowers are borne on slender pedicels one-twelfth to one-sixth of an inch long instead of being sessile as in red clover, and, as they mature, become reflexed or turned down so that the upper and lower part of the head during the maturing period are separate. The pod, a thin-walled elongated legume, is one to four, usually two to three, seeded and has a persistent style. Ripened flowers readily fall from the plant, hence care is required in handling the crop for seed. Threshing is less difficult than with red clover, but the crop must be cured thoroughly, else seeds will be crushed in threshing.

Alsike clover on the left; red clover on the right. Taken at Cornell Station June 28. One-fourth natural size

178. Value.—Alsike clover may be grown for hay or for pasture. For hay it is chiefly valuable for growing on those soils where red clover does not grow readily, or for growing under those climatic conditions where red clover is easily killed. In many sections a mixture of red and alsike clover with or without timothy is desirable. The alsike clover does not retard the red clover greatly and when the latter fails to grow or is killed the alsike develops more freely and in a measure takes its place. The first crop of alsike clover matures about the same time as red clover; the second crop is comparatively small. The seeds are formed in the first crop. It bears seed abundantly, and in some sections it is considered especially desirable for this purpose. No direct experiments with regard to the relation of insects to pollination have been made, although the flower is essentially like that of white clover. It produces an abundance of honey of high quality, and is prized by bee-keepers for this purpose.

For mixture in temporary pastures it serves an excellent purpose. For permanent pastures it is not as desirable as white clover, because of its less perennial (three to five years) and less creeping habit, and because it is less readily eaten by live stock, probably on account of its slightly bitter taste.[1] The Tennessee Station reports that, when pastured exclusively upon alsike clover, horses and mules may be affected with serious lesions of the skin and mucous membranes.[2]

179. Seed and Seeding.—The seeds of alsike clover are wider than long, about 0.04 inch long, 0.05 inch wide and 0.024 inch thick. By weight they are about one-fourth larger than those of white clover and about one-half the size of red clover seeds. There are about 700,000 seeds to the pound. The radicle varies from beyond one-half to nearly the whole length of the seed and projects prominently, thus usually giving a distinctly heart-shaped appearance to the seed. The color is varied and frequently mottled from yellow to green, the predominating color being olive green. Old seeds become reddish brown and are sometimes dyed green to give fresh appearance, which may be detected by rubbing with a white cloth. The purity of commercial seed is generally rather better than with red clover, while the germinating power is not so good. The standard of purity should be 98 per cent. and of germination not less than 75 per cent. Canada thistle seed and wire grass or Canada blue grass seed are more common than in red clover seed, doubtless due to the region in which the seed is chiefly produced. The viability of the seed is not



Alsike clover pod on the left; single seed on the right. Enlarged four times.

[1] Stebler and Schröter: Best Forage Plants, p. 86.

[2] Tennessee Sta. Bul. Vol. XVIII (1905), No. 3.

known. Seedsmen usually furnish 60 pounds for a bushel, but the actual weight for a measured bushel is much greater—about 90 pounds.

Except for seed, it is not desirable to sow alsike clover alone. In this case eight pounds of seed to the acre, or about 125 seeds a square foot, may be sown. A good mixture for hay is timothy 15, red clover 6, and alsike clover 4 pounds. When grown with timothy, aliske is easily cured and makes a hay of excellent quality. Without timothy, 8 pounds of red clover and 6 pounds of alsike may be used. Even where alsike hay is chiefly desired, the addition of some timothy—say four pounds timothy seed and eight pounds alsike seed—is desirable, because timothy helps to prevent the alsike from being blown down and also facilitates the curing.

180. History.—Alsike clover appears first to have become extensively cultivated in Sweden at the village of Syke or Alsike near Upsala, whence in 1834 it was introduced into England. At the end of the preceding century it had been introduced into northern France, but its cultivation in parts of Europe, as in Switzerland, is quite recent. There is no record of its first introduction and use in America.

II. WHITE CLOVER

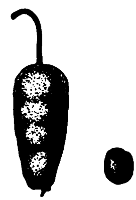
181. Description.—White clover (*Trifolium repens* L.), also commonly known as Dutch clover, differs from alsike clover in its shallower root system (mostly within the first six inches of the soil), its prostrate and creeping habit, and its smaller size. (176) The leaf and flower stalks are relatively long. The latter do not arise from erect leafy stems, as in the case of alsike clover, but arise directly from prostrate stems or stolons, which constitutes a ready means of distinguishing the two species. The prostrate stems root freely at the node from which may arise independent plants. This habit, together with its perennial character, causes the plant to spread rapidly and form a fairly dense sod. The pod, very similar to that of alsike, contains on an average a large number of seeds—usually three to four, sometimes five or six. The seed resembles that of alsike in shape, but is smaller and of different color. The solid color varies from orange, sometimes red, to yellow when fresh, changing to reddish-brown when old.

Giant broad-leaved white clover, an improved variety of white clover imported from Italy, was tried at the North Carolina Station. The plant was reported to be much more robust, to have larger leaves, and to produce twice the herbage, but a small quantity of seed.

182. Distribution and Adaptation.—White clover is indigenous or naturalized commonly throughout North America, Europe, parts of Asia, and northern Africa. It is less sensitive to climate, especially cold, than is red clover. It thrives best in a moist but well-drained soil, particularly in one with plenty of lime and humus. While it needs warmth and moisture, it withstands drought better than does red clover. The application of lime, potash, and phosphates increases its growth. The effect of wood ashes in bringing in white clover where none was noticed before is more marked than with red and alsike clovers. (157) An abundant growth of white clover is an indication of a productive soil. This clover holds the same relation to Kentucky blue grass that red clover does to timothy. It is suitable for pasture only, for which, in connection with Kentucky blue grass, it is unexcelled. It stands pasturage well and is not likely to cause bloat in cattle as is the case with red clover.

During August, when the white clover contains an abundance of seed, it causes horses pastured upon it to "slobber"—probably because of the acrid nature of the seed, a characteristic of all clovers. White clover is highly prized as a honey plant.

183. Seed and Seeding.—White clover is rarely adulterated, but old seeds have been rubbed with flowers of sulphur to give them a fresh yellow color. The weed seeds are about the same as those occurring in red clover. Commercial seed, about 800,-000 to the pound, should have the same standard of purity and of germination as alsike clover, 98 and 75 per cent. respectively. The plant seeds freely: European authorities report 4 to 15 bushels an acre. The seed may evidently remain in the soil several years and still grow. Its viability is, therefore, considered better than that of other clovers, although this has not been proved. The percentage of "hard" or dormant seeds is said to be higher than in red clover. Stebler examined a pound of the dried residue from liquid manure which had been left in a barrel and found it to contain 5,370 seeds with a germinating power of 62 per cent. The reason for the occurrence of white clover in fields which have been manured with stable manure is not far to seek. According to Darwin's experiments, white clover may produce seed sparingly without the intervention of insects, but most of the seed is produced by cross-fertilization.



White clover. Pod on the left, single seed on the right. Enlarged four times.

Considerable white clover seed is harvested in eastern Wisconsin. The seed is produced in the first crop. In Wisconsin it is harvested from July 20 to August 1. Self-seeded fields furnish the bulk of the crop, from which it is cut year after year. When the growth is large enough the buncher is used. (165) Otherwise there is attached to the cutter bar of the mowing-machine a platform made of galvanized iron. Holes are drilled through the back of the bar and the platform attached with bolts. As the clover gathers upon this platform, a man following the machine rakes it off into bunches. After curing a few days it is threshed with the clover huller. (166)

White clover is not largely sown, but finds its way into pastures which are suited to it. It is very unevenly distributed in the field and grows very unequally in different seasons. It is never sown alone but in mixtures at the rate of two to six pounds an acre. It constitutes a part of many lawn mixtures.

III. CRIMSON CLOVER

184. Relationships.—Crimson clover (*Trifolium incarnatum* L.), also known as scarlet clover and carnation clover, differs from other commonly cultivated clovers in America in that it produces seed within less than a year from seed. Crimson clover is closely related to the smaller wild rabbit foot or stone clover (*T. arvense* L.), commonly naturalized from Europe throughout the North Atlantic and southern states.

185. Description.—Crimson clover has a strong, branched tap root and numerous secondary branches reaching to a moderate depth. Under greenhouse conditions tubercles are found abundantly upon roots when the plant is three to four weeks old. Six to twelve branches or stems one to three feet high arise from the axils of the leaves of the short main stem: they are but little branched and grow quite erect, giving the plant a bushy appearance. The vegetative parts are characterized by their hairy, almost woolly, appearance. The densely flowered cone-like heads are one to one and a half inches in length and three-fourths to one inch in diameter. The calyx has short and prominent teeth and is very hairy; the hairs become spiny as the head matures. The color of the corolla may be scarlet, flesh-colored, whitish or yellowish, depending on variety. The time of flowering varies

Crimson clover heads. Middle one has been injured by clover-root mealy bug (*Pseudococcus trifolii* Forbes). One-third natural size. (From photo by Garman) from April to June, depending on locality, time of seeding, and the variety.

186. Varieties.—The common form has scarlet flowers, but there is another commercial form in the United States which has white flowers and is said to be taller, less hardy and two to four weeks later in flowering. In Europe strains of the crimson type with different periods of blooming are recognized.

"Ordinary *Trifolium incarnatum* blooms the last of May. There is an earlier variety which blooms eight days sooner. A later variety, called St. Johns, cultivated for a long time about Toulouse, prolongs the ordinary harvest at least two weeks. A white-flowered variety, obtained by Lejeune and propagated by Vilmorin, is said to be still later by ten to fifteen days. A yet later variety with red flowers blooms after this last. By sowing these five varieties, we can continue the ripening of the green forage from the beginning of May to the end of the first two weeks of July, at least."[1]

187. Distribution and Adaptation.—Crimson clover is cultivated principally in the South Atlantic states, especially in those states north of the cotton belt. It is not generally adapted to the climate north of the fortieth parallel, except on the Pacific coast. It does best on sandy soils in warm, moist climates. Since it cannot endure much freezing nor extreme heat and drought, its distribution as a cultivated plant is rather limited. The Alabama Station has shown that in some instances its failure to grow successfully may be due to lack of inoculation, but that probably where clovers of any kind will grow artificial inoculation is unnecessary.[2]

188. Value.—The principal value of crimson clover is as a cover crop in orchards and as a renovating crop in rotations, the fall sown crop being plowed in time to plant maize or cotton. It may be used for winter pasturage or for soiling, but it is not generally satisfactory for hay, on account of its woolly

[1] Gano: Thesis: The True Clovers, pp. 79, 80; quoted from C. Garola: Plantes Fourragères, 1904.

[2] Alabama Sta. Bul. No. 87 (1897), p. 477.

character and the harshness of the flower heads. It has been reported to injure cattle by forming "hair balls" in the digestive tract.[1] The Delaware Station recommends it for silage.[2]

189. Seed.—The seed of crimson clover is enclosed in a capsule which opens transversely as in the case of red clover. The seeds are relatively large, 125,000 to 150,000 to the pound. Seedsmen usually sell 60 pounds for a bushel. This clover is not usually adulterated in this country, but in Europe berseem seed is used, and is difficult to detect because of the similarity in size, shape and color. Berseem seed is less glossy, is less uniformly and perfectly oval, the radicle being more apparent, and usually the hilum and surrounding portion are darker colored. The standard of purity should be 98 per cent. and of germination 90 per cent. The seeds are said to deteriorate rapidly with age. They are 0.09 to 0.12 inch long, 0.06 to 0.07 inch wide and 0.05 to 0.06 inch thick. The radicle, which is at least one-half the length of the seed, is not prominent. The seeds are, therefore, quite globular. The color is reddish-gold, or straw-yellow, varying to brownish. The hilum is usually fringed with reddish-brown, a trace of which may extend toward the end of the seed. When seeds are old they become wrinkled and brown.

Crimson clover is raised chiefly in Delaware and surrounding states. One method is to sow buckwheat in July or August with a grain drill, using three-fourths of a bushel of seed per acre, and follow with crimson clover, using a wheelbarrow seeder, at the rate of one peck of seed per acre. The buckwheat is harvested in the fall, and the crimson clover the following spring. Crimson clover is also sometimes sown in maize at the last cultivation.

In cutting crimson clover for seed, it is necessary to cut in the night time or early in the morning when the dew is on, in order

[1] U. S. Dept. Agr., Div. Agros. Circ. No. 8.
[2] Delaware Sta. Bul. No. 16 (1892).

to prevent seed from shattering. The self-rake reaper is considered the most satisfactory machine for harvesting. Threshing should be done as soon as possible, since the seed sprouts readily if exposed to damp weather. Stacking is not desirable, since heating is liable to cause seeds to turn dark. Five bushels, and in some instances ten to twelve bushels, of seed per acre may be obtained.

190. Seeding.—Although sometimes sown in the spring, crimson clover is usually sown in August or September and harvested the next May or June. Generally it is sown alone—that is, without mixture of grasses or other clovers and without a grain or nurse crop—usually at the rate of 10 to 20 pounds of seed per acre. It is sometimes sown with rye for soiling.

191. History.—Crimson clover was probably cultivated from somewhat early times among the Pyrenees in southern France

Root tubercles on berseem. The roots belong to a plant five months old grown in the greenhouse in rather sandy soil, but without any artificial inoculation
(From photo by Gano)

and northern Spain. In other parts of Europe it has been chiefly cultivated only in the last century. While grown in Chester County, Pennsylvania, as early as 1820, its principal use has taken place since 1890.

IV. MINOR CLOVERS

192. Berseem (*Trifolium alexandrinum* L.), also known as Alexandrian clover and Egyptian clover, is an annual with ascending but not very erect stems, two to three feet, and sometimes under irrigation, five feet high. These stems are glabrous and smooth, and rather succulent until the flowering period. The leaflets are more elongated and longer than in red clover, and softly hairy on both sides. The flower heads, smaller and less densely flowered than in red clover, are borne on axillary stalks near the tip of the stems. The flowers are white or cream-colored. The pod is one-seeded, the seeds resembling those of crimson clover. (189) The root system is shallow, but abundant. The roots are characterized by the large tubercles which they bear.

Berseem is the one great forage crop of Lower Egypt. "Few single species in any country play a more important role in agriculture. It furnishes the green fodder for all work animals in the towns: all beef and milch animals are fed on it: well kept donkeys and even poor fellahs use it for food."[1] It has been introduced into America with the hope that it may be found useful in the warmer irrigated sections, but its place, if any, has not yet been established.

193. Hungarian Clover (*Trifolium pannonicum* Jacq.) has white, creamy or yellowish flowers in dense spikes. Otherwise its appearance and habits of growth are similar to those of mammoth clover. Since it is perennial, it is believed that it might have a place for certain agricultural conditions. It seems, however, to produce seed sparingly and of a rather low germinating power. It is said to be earlier than red clover, but not as well liked by cattle. It is indigenous to Hungary, and has been successfully cultivated for hay in Europe, where it is also used for ornamental purposes.

194. Yellow Suckling Clover (*Trifolium filiforme* L.) is a small annual, shallow rooted, procumbent plant with somewhat the habit of growth of white clover. It is smaller and does not seem to root at the nodes freely, if at all, as does white clover. There are only five to six flowers to a head; they are yellowish, pedicelled and finally reflexed. The seed pod normally contains one seed. The oval seeds are rather smaller than those of white clover, smooth, glossy, and vary in color from golden-yellow to brown. It is native to England and southern Europe, and is said to prefer sandy soils on which it is recommended for sheep pasture. It is seldom sown.

[1] U. S. Dept. Agr., Bu. Pl. Ind. Bul. No. 23 (1903).

195. COLLATERAL READING.—F. G. Stebler and C. Schröter: The Best Forage Plants, pp. 83-8. London: David Nutt, 1899.

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Harcourt A. Morgan and Moses Jacob: Alsike Clover. Tennessee Station Bul. Vol. XVIII (1905), No. 3.

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Thomas A. Williams: Crimson Clover. U. S. Dept. Agr., Div. Agros. Circ. No. 17, 1899.

X

LEGUMINOUS FORAGE CROPS

I. ALFALFA

196. Relationships.—Alfalfa or lucerne (*Medicago sativa* L.), also known as purple medic to distinguish it from other species of the genus, belongs to the same tribe (*Trifolieae*) as the true clovers (*Trifolium*) and the sweet clovers (*Melilotus*), all being characterized by the three leaflets into which the leaf is divided. A number of species of Medicago have been either grown in America or tested by the experiment stations. These are black medic (*M. lupulina* L.), bur clovers (*M. denticulata* Willd. and *M. maculata* Willd.), snail clover (*M. turbinata* Willd.), sand lucerne (*M. media* Pers.), and yellow lucerne (*M. falcata* L.). The last two are sometimes considered by botanists as varieties of alfalfa (*M. sativa* L.), but they differ widely in agricultural value. The name alfalfa is Spanish, *al* = the article *the*, and *falfa* = *fazfazah* (Arabic), meaning "a certain plant used for fodder." The earlier Spanish form was alfalfez.

197. Roots.—Alfalfa is characterized by its strong deep growing tap root. The depth depends on the age, character of the soil and the depth of the permanent water table. In some instances roots will have reached the depth of five feet in six months, while those of old plants have been known to grow extraordinary depths. (130) The tap root is usually under one-half inch in diameter just below the crown, and grows without many secondary roots nearly to its end where it divides into a few branched roots of about equal size.

Sometimes several roots set off from the tap root near the crown. These are large like the tap root and extend directly downward as deeply as the tap root or nearly so. In some cases the roots are two to three inches in diameter, but this usually occurs where the tap root is cut off or is prevented from penetrating the soil to any great depth. Roots do not enter the permanent water table more than four to eight inches. They do not decay nor die, but simply stop growing. On account of the lack of fibrous roots and the depth of the branched end of the tap root a much deeper proportion of the feeding surface of the roots is in the sub-soil, the character of which is very important to this crop. Although desirable, it is apparently not necessary that the sub-soil be friable. Roots will penetrate a hard tenacious clay if not prevented by the occurrence of a permanent water table.[1]

Under proper field conditions root-tubercles begin to occur not later than two to three months from sowing. They are elongated oval, not very conspicuous, occurring on both the main and the fibrous roots. According to Passerini, root-tubercles are more abundant during the first season than thereafter.[2]

198. Habit of Growth Above Ground.—The young seedling throws up a single stem, but as it grows older other erect stems arise from the crown. With older plants in the spring under field conditions, 3 to 12, sometimes 20 to 30, erect stems 6 inches to 60 inches tall, usually 18 to 30 inches, arise from the crown. Plants growing alone may have from 150 to 200 stems. The underground portion of these stems elongates slightly and thus the crown becomes branched. On these branches new stems and new roots may arise. If these branches are split apart, several plants may be formed from a single plant. When the crop is mown during the growing season,

[1] Colorado Sta. Bul. No. 35 (1896).

[2] Bul. Soc. Bot. Ital., 1900, pp. 16, 17.

new stems arise both from the crown and from the remaining portions of the clipped stems. Rather short, leafy branches arise from the stems having a distinctly smaller diameter than the stems from which they arise. The Colorado Station reported the average diameter of 300 stems at one-sixth of an inch. The proportion of leaves to stems at early maturity is about 40 leaves to 60 stems, according to the Colorado Station, while according to the Minnesota Station the nitrogen in leaves and stems was about 60 to 40.

Alfalfa plant taken July 17, six days after second cutting. Picture shows stubs remaining from first cutting; stubs from second cutting with new shoots arising therefrom and new shoots arising from the rhizome; also shows rhizome branched and split apart.

The lateral leaflets are on the side of the leaf-stalk, *pinnate,* instead of at the end, *palmate,* as in the clovers, and readily fall off during curing and handling. The leaflets are more elongated and pointed than in red clover, and are quite variable in size, but are generally much smaller, usually three-fourths to one inch long and three-eighths to one-half inch wide. The veins of the leaflets end in more or less prominent teeth. Although on close examination the vegetative parts may be slightly hairy, the general appearance is that of a smooth or glabrous plant.

199. Inflorescence.—Six to a dozen or more purple flowers are borne in a short raceme, which as the flowers mature forms a more or less head-like cluster. Each flower is on a short, slender pedicel, which makes its removal from the flower head easy.

Raceme of alfalfa flowers taken at Cornell Station Sept. 12. Natural size

Hildebrandt has shown that seeds may form without the visitation of insects.[1] Hunter reports an experiment in Kansas where the honey bees increased the crop two-thirds over fields not visited by bees.[2] The quality of the honey was excellent. Alfalfa, however, would be valuable as a honey crop only when grown for seed, since when cut for hay comparatively few flowers are allowed to develop. Among practical seed growers the

[1] Stebler and Schröter: The Best Forage Plants, p. 146.
[2] Contrib. Ent. Lab. Univ. Kansas, 1899, No. 65.

visitation of insects is not recognized as a factor in the abundance of seed. As the pistil grows into a pod it becomes a spiral legume with two to four turns and is many-seeded.

200. Seed.—Alfalfa seeds are distinguished from seeds of closely related plants somewhat by their color, size, and shape, although the shape is quite variable, owing to the occurrence of several seeds in the spirally-twisted seed pod. Viewed laterally, they vary from nearly oval in the smaller specimens to distinctly kidney-shaped in the larger ones. The radicle (caulicle) is half, sometimes a little more than half, the length of the seed; it is distinct, but not prominent. The tip of the caulicle does not usually project, and this chiefly in the kidney-shaped specimens. The larger seeds especially are curved, and even in some instances spirally-twisted. The color of the individual seed is uniform, except for the darker markings about the scar and a light stripe which may occur along the raphe. Alfalfa seed may be distinguished from red clover seed by its uniform light olive-green color as contrasted with the purple and yellow of the latter. Alfalfa seeds are usually 0.08 to 0.12 inch long, and 0.05 to 0.07 inch wide. The number of seeds a pound may vary from less than 200,000 to more than 240,000; perhaps 225,000 would be a fair average. Sixty pounds are sold for a bushel.

Alfalfa showing clusters of seed pods. *a* Single pod enlarged

201. Adulterations and Impurities.—Alfalfa seed has been extensively adulterated with black medic seed imported from Europe. (236) Recently enacted laws will probably prevent the practise hereafter. Sweet clover seed sometimes occurs, although rarely as an adulteration. (250) Probably it more frequently occurs because of the presence of this plant in alfalfa fields. Seeds of the bur clovers have been rather extensively used as an adulterant in Europe, since these plants are widely distributed in South America, the hooked pods of which gather in the wool of sheep, the seed thus becoming a by-product in the manufacture of woolen cloth. (238) The most common impurities in alfalfa seeds as found in 53 samples by the Nevada Station,[1] and in 15 samples by the Ohio Station,[2] are as follows: clover dodder (*Cuscuta epithymum* Murr.), field dodder (*C. arvensis* Beyr.), lamb's quarters (*Chenopodium album* L.), western atriplex (*Atriplex truncata* Torr.), prostrate amaranth (*Amaranthus blitoides* S. Wats.), green foxtail grass (*Chaetochloa viridis* (L.) Scribn.) and witch grass (*Panicum capillare* L.).

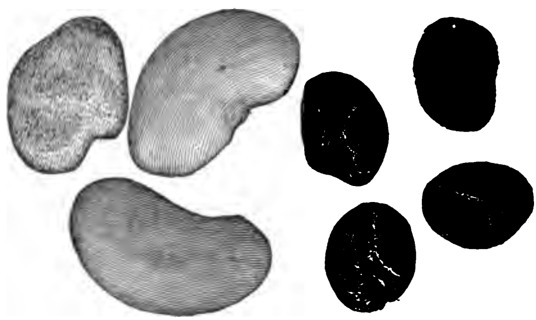

Alfalfa. Pod on the left, single seed on the right. Enlarged four times

202. Dodder.—By far the most serious impurity in alfalfa seed is the dodder, of which there are now recognized to be three species occurring on either red or mammoth clover or alfalfa—namely, field dodder (*Cuscuta arvensis* Beyr.), alfalfa dodder (*C. epithymum* Murr.), and clover dodder (*C. trifolii* Bab.). The first species is sometimes referred to as large seeded dodder, while the last two species are not usually separated and are commonly called clover or small seeded dodder. The species most commonly occurring in commercial seed and upon alfalfa

[1] Nevada Sta. Bul. No. 47 (1900), p. 11.
[2] Ohio Sta. Bul. No. 142 (1903), p. 121.

appears to be the small seeded alfalfa dodder (*C. epithymum* Murr.). Field dodder occurs on many plants, especially southward, where it is known as love vine; while the small seeded dodder seems to be pretty closely restricted to clover and alfalfa.

The habit of all these species is similar. The seeds germinate in the soil, but the plant soon attaches itself to the alfalfa or other plant by means of suckers, the thread-like stem of the plant twining about the stem of its host. The leaves are reduced



Alfalfa seed on the left, dodder seed on the right. Both enlarged
(From photo by Slingerland)

to minute alternate scales. In the small seeded species the seeds are red and the small flower pinkish; in the field or large seeded dodder the stem is yellow and the flowers greenish white. In the clover dodder the seeds are uniformly dull gray, oval or roundish, less than 0.04 inch in diameter; in alfalfa dodder the seeds are reddish-yellow, elongated rather than round, 0.04 inch long by 0.02 inch wide; in field dodder the seeds are bright orange-yellow, somewhat angular, presenting their somewhat flat surfaces with angles betewen, 0.04 and 0.05 inch in diameter.

The seeds of the large seeded dodder being about the size of those of alfalfa are rather difficult to remove, but the smaller seeded dodder can be readily removed by means of properly adjusted screens.[1] As the plant grows upon the alfalfa, the latter is killed and the dodder spreads to adjacent plants in an ever-widening circle. The dodder may be destroyed by plowing and using the field for cereal crops for two or more years, taking care to apply the manure from the dodder-infested alfalfa hay only to land that will be devoted to cereals, potatoes, or other cultivated crops. If only a few small patches occur, these may be mown, the stubble sprinkled with kerosene, covered with the hay, and burned. According to the New York State Station, the small seeded dodder rarely seeds in that locality, but passes the winter on crowns of alfalfa, clover, black medic, and fleabane (*Erigeron ramosus* (Walt.) B. S. P.).

203. Germination and Viability.—The standard of purity should be 98, and the standard of germination 90 per cent. It is said that the percentage of hard seed is often high, but diminishes with age. While the viability of alfalfa seed is not definitely known, two and three-year-old seed is considered quite as good as fresh seed. The Colorado Station found that prime seed lost only 2.5 per cent. of its germinating power in ten years. Another sample showed a germinating power at six years of 93, at ten years of 72, and at sixteen years of 63 per cent.[2] Dead seeds, instead of light olive-green, are brown.

204. Varieties.—A number of slightly different strains of alfalfa have been grown by experiment stations, while Turkestan and Grimm alfalfa have been tried somewhat more widely.

Among these may be mentioned: American strain alfalfa, a hardy sort recommended for northern United States; French alfalfa, originally from France, but developed in North Dakota; Oasis alfalfa, obtained from Tunis, North Africa, and said to be a promising drought-resistant sort; Solover or

[1] Construct a light wooden frame, 12 inches square by 3 inches deep, and tack over the bottom 20x20 mesh steel wire cloth made of No. 34 (W. and M. gauge) wire. Put in the sieve 4 to 8 ounces of seed and shake vigorously for 30 seconds. Samples of alfalfa seed for analysis should be taken from the bottom of the bag, since jarring is likely to cause the small dodder seeds to fall through the alfalfa seed.

[2] Colorado Sta. Bul. No. 110 (1906), p. 11.

Utah alfalfa, grown from Utah seed and said to be a hardy and vigorous grower for arid and semi-arid regions; Samarkand alfalfa, a shorter, more hardy and more drought-resisting variety.

Turkestan alfalfa was introduced into the United States from the arid regions of Turkestan in Asia in 1898 with the idea of extending the northern limit of alfalfa growing in the United States. It has been widely distributed and tried, but reports are somewhat conflicting. In the eastern and humid states it does not seem to be superior to common alfalfa. Reports from the region west of the Mississippi River and north of the fortieth parallel indicate that it is hardier and more productive than that commonly grown there. It is said to endure drought better, is less easily affected by freezing, and gives better results on strongly alkaline soils. It is claimed that the root system is stronger, that stems are more slender and more leafy, thus making hay of finer quality. These differences are not sufficiently marked to be noticed by the casual observer.

Grimm alfalfa is a strain that has descended from plants which had survived about 20 years in the vicinity of St. Paul, Minnesota. It is, therefore, recommended for sowing in northern climates. It is claimed to be more thrifty and more vigorous than common alfalfa. It is said also to produce seed more abundantly.

"Our common alfalfa presents two types, readily recognized by the growers; one has a dark green color and narrow leaves with red stems and usually deep violet purple flowers, while the other has green stems and much lighter flowers. The former is leafier and earlier than the latter, but is possibly a little less vigorous grower. In the color of its leaves and habit of plant the former resembles the Turkestan."[1]

205. Distribution.—Alfalfa is cultivated more or less in all countries of mild climate in the world. It is extensively cultivated in South America.

[1] Colorado Sta. Bul. (1906), p. 4.

"Alfalfa occupies one-sixth the cultivated area of Argentina. It has caused the development without irrigation of vast areas of semi-arid land in the northern and western portions of Argentina. It is estimated that about eight acres of natural pasture are required to supply one steer, but that one acre of alfalfa will support the same animal. Besides being pastured, it is used extensively for hay, and is exported in no inconsiderable quantities."[1]

Over three-fourths the area in alfalfa in the United States in 1899 was in the western states, while over 98 per cent. was grown west of the Missouri River. Since that time alfalfa growing has increased somewhat in the eastern states. Although the distribution is in large measure influenced by its adaptability, it is also to some extent influenced by the fact that east of the Missouri River timothy, red clover, and other grasses and clovers thrive relatively better than they do west of the Missouri River.

206. Adaptation.—Alfalfa is naturally adapted to a warm climate. Kansas raises much more than Nebraska, South Dakota much less, while North Dakota raised scarcely none at all in 1899. About two-thirds the area in hay in New Mexico was in alfalfa; in Colorado one-half; in Wyoming one-fifth; while in Montana only one-fourhundredth part of the area in hay was in alfalfa. Owing to its deep-root system alfalfa is highly drought-resisting and is also well adapted to irrigation. An excess of rainfall as well as an excess of water in the soil is injurious. It thrives better in an alkaline than an acid soil, being fairly alkaline resistant. The sub-soil is more important than the soil, probably because of the effect of the former upon the water table rather than because of its permeability to the roots or the plant food contained therein, although both of the latter are important.

[1] The Author: How to Choose a Farm, p. 358.

Calcareous soils, particularly in the humid regions, are especially adapted to this plant. Hence where the soil and the subsoil are friable, and contain a large quantity of lime, alfalfa will thrive even though the rainfall be as high as 35 to 40 inches annually. Soils of the Miami series, especially Miami stony loam and Miami gravelly loam, are, when properly drained, either naturally or artificially, well adapted to alfalfa. In general, the chocolate-colored river bottoms and maize and oat lands rather than wheat and grass lands are the best adapted to alfalfa. (C. A. 115)

207. Conditions Affecting Success with Alfalfa.—The controlling factors in the culture of alfalfa are (1) the climate; (2) the character of the soil; (3) the treatment of the soil, including additions of lime and fertilizers; (4) inoculation with alfalfa bacteria; (5) the kind and quantity of seed; (6) the time of seeding; and (7) the after treatment of the crop.

In the western states where alfalfa is chiefly grown, it grows so readily, especially when irrigated, that seed is in some cases sown without any preparation of the soil, except the removal of the sage brush by hitching a team at each end of a railroad iron and dragging it over the ground. Between this condition and a condition that requires the greatest care there are many degrees.

208. Treatment of the Soil.—Alfalfa is not stoloniferous and cannot spread except slightly as previously indicated. (198) It does not take possession of the soil and crowd out other plants as may Kentucky blue grass or white clover. On the other hand, grasses and weeds will take possession of the land between the alfalfa plants and reduce their growth. It happens that those soils least adapted to alfalfa are best adapted to grasses, and hence on such soils grasses are likely to obtain the ascendency. For this reason the previous treatment of the soil should be such as to bring about the most vigorous growth of alfalfa and clean the soil of weeds and weed seeds. This is best brought about by a crop which has been heavily manured with stable or other organic manure and has received thorough inter-cultural tillage. In Europe, the root crops furnish this condition; in New York State peas raised for the canning factories seem to furnish the ideal condition; while in the north and south central states the maize crop furnishes the appropriate previous preparation.

While an addition of stable manure at the rate of 20 loads to the acre just before preparing the land for alfalfa is objectionable from the standpoint of adding weed seeds, yet experience has demonstrated that this is usually good practise and upon some soils essential. On many soils in humid sections lime should be added at the rate of 1,000 to 3,000 pounds an acre. Assuming the land to have been in an inter-tilled crop the previous year, the manure may be spread during the winter or spring, the land plowed two to three weeks, and the lime added about a week before seeding and immediately worked into the soil with a spring tooth or disk harrow.

The subsequent preparation of the soil should be such as thoroughly to incorporate the manure and the lime with the soil and to prepare a seed-bed suitable to receive and germinate small seeds. This may be accomplished by means of a spring tooth harrow and a roller or wooden drag. (C. A. 299) A disk harrow is also desirable in order to secure deeper preparation, but is not essential.

The above discussion applies more especially to the humid sections of the United States. In the sub-humid sections there is no trouble to get a stand if the soil is well prepared. Since the incorporation of stable manure in the soil is likely to cause it to dry out too rapidly where the rainfall is deficient, it is better to top dress after a stand has been secured. West of the Missouri River no lime is needed.

209. Inoculation.—For soils only moderately well adapted to the growth of alfalfa, three conditions have seemed desirable if not essential to success: (1) the application of an abundance of manure; (2) the application of lime; and (3) the artificial introduction of bacteria accustomed to growing in alfalfa root-tubercles. This inoculation can be successfully accomplished by putting the living organisms upon the seed immediately before seeding, or by sowing upon the soil just before seeding from 100 to 400 or more pounds, of soil from an alfalfa field where the tubercles are abundant. (139) The latter method has been more largely practised and has been found in a large percentage of cases to improve the stand, and during the first season at least, result in a large number of root-tubercles of a more vigorous growth. Generally in such cases few, if any, root-tubercles occur during the first season on the uninoculated soil, while they are abundant on the inoculated soil, the relative vigor of growth depending on the abundance of inoculation and on the fertility, presumably especially on the abundance of soluble nitrogen in the soil. The more abundant the root-tubercles the greater the difference in growth; the more abundant the soluble nitrogen the less the difference in growth. Generally in these trials the uninoculated fields or plats make such poor growth that they are plowed up at the end of the first year, hence there are few observations on the relative yields obtained the second season from the inoculated and uninoculated areas. Results at the Cornell Station indicate an increased yield of hay from the inoculated areas.[1] The Alabama Station first called attention to the increased vigor of alfalfa through inoculation by incorporating in the soil dust from bur clover soil. The increase in hay attributable to inoculation was 336 per cent.[2]

[1] New York Cornell Sta. Bul. No. 237 (1906), p. 156.

[2] Alabama Sta. Bul. No. 87 (1897), p. 477.

210. After Treatment.—For its best growth the young alfalfa plant requires an abundance of soluble nitrogen in the soil. If it has not been applied by means of stable manure, and even if stable manure has been used, 100 pounds of nitrate of soda may be sown two to three weeks after alfalfa has been seeded, if the alfalfa lacks at this time a deep green color. If sown without grain or nurse crop, it should be clipped well above the crown in the latter part of June or early in July in order to retard the growth of weeds and cause the alfalfa to produce a larger number of stems and thus shade the ground more fully. Doubtless, also, this procedure helps in humid climates to check the leaf-spot. (218) Subsequent clippings will depend upon the growth of alfalfa and weeds, but usually another should be given sometime in August. When a nurse crop is used, the cutting of this answers for one of the clippings. (216) Old meadows are sometimes worked with a disk harrow. It is claimed that this method splits the crown and thus increases the number of independent plants, and thereby increases the yield. Old meadows also respond to the application of stable manure spread upon the land, preferably with a manure spreader immediately after the last crop.

211. Irrigation.—The soil may be irrigated before seeding, but after the plants have started the land should not be irrigated the first season, because the soft mud may cover the small plants and kill them. Usually irrigation is not necessary to grow the first cutting. For the second cutting, the land may be irrigated immediately after the first crop is harvested, or about one week before it is harvested, which is believed to give the best results. The Utah Station has shown that less water is required to grow fair crops when applied at intervals of three to four weeks. The Wyoming Station applied 2.22 acre-feet of water during the season to alfalfa when the rainfall was about 1.5 inches. The Colorado Station recommends 20 to

24 inches of water to produce the three crops usually grown. No rule, however, can be laid down as to the amount of water required, since this will depend on the climate, soil, and position of the ground water. Indeed, in many instances the ground water at a depth of from four to twelve feet constantly fed by seepage from rivers or canals is sufficient for the growth of alfalfa without irrigation. The water is usually applied by the system known as flooding, from two to ten hours being required. The amount should not be sufficient to allow pools of water to stand after the water is turned off, else the alfalfa will be killed.

212. Rotations.—The economic duration of an alfalfa field varies greatly with climate and soil. The author saw a field in Nevada which had grown alfalfa 18 years continuously without re-seeding or the addition of seed. Grass was somewhat abundant, but satisfactory crops of alfalfa were still being harvested. Usually other things equal, the largest yields are obtained the second and third years (third and fourth from seeding), while thereafter there is a decrease in yield from the gradual dying out of plants. The rotation practised around Greeley, Colorado, where potato growing is an important industry, is about as follows: potatoes two years; wheat one year; barley or oats, with which the alfalfa is seeded, one year; alfalfa three to four years.[1] Wing recommends for humid sections: maize one year; barley, with which alfalfa is seeded, one year; alfalfa four years.[2] For eastern Kansas five or six years of alfalfa followed by cereals in rotation for twenty years is recommended. By having five fields, one field or one-fifth of the farm may be in alfalfa all the time.

213. Quantity of Seed.—While 25 plants to the square foot is considered an excellent stand for a new seeding, and in old meadows good yields of hay may be obtained with five plants

[1] U. S. Dept. Agr. Yearbook 1904, p. 313.

[2] Pennsylvania State Dept. Agr. Bul. No. 129.

to the square foot, yet alfalfa is perhaps seldom injured by heavy seeding, but often it would be better if more seed had been used, although the practise varies from 15 to 30 pounds per acre or from 75 to 150 seeds per square foot. Probably in no case should less than 20 pounds per acre be sown, except where grown for seed. For seed it is customary to sow from 12 to 16 pounds per acre. When grown for hay the only advantage to be gained in sowing 20 rather than 30 pounds of seed is the saving in the cost of the seed. Thick seeding is an advantage, because the alfalfa stands better, the hay is a better quality and weeds are subdued.

214. Time of Seeding.—Assuming suitable weather conditions, alfalfa may be sown any time during the growing season, —say between April 1 and October 1. Generally speaking, the best time is during the month of April; in some sections the second best time is during August or September, depending on locality, while the poorest months are June and July. In regions having very light rainfall in autumn seeding should be done in the spring. Alfalfa, being a warm weather plant, should not be seeded as early in the spring as the clovers. The best time for sowing alfalfa is midway between the best time for sowing oats and that for planting maize. One reason why satisfactory results are not obtained in sowing with oats is that the seeding is apt to be done to suit the oats and not to suit the alfalfa.

215. Method of Seeding.—The depth of seeding must depend on the soil and climate, the drier the climate and the sandier the soil the deeper the seeding. In general, the seed should be covered deeper than red clover. In humid climates, good results are obtained by sowing with the seeder attachment to the grain drill, adjusting the spouts so as to deposit the seed in front of the hoes. In the more arid sections, the grain drill itself is used, the alfalfa being mixed with soil, maize meal or bran to cause the seed to feed evenly. In this case the seed is covered from 1 inch to 1.5 inches deep. One-half the seed is sometimes sown one way and then the other half crossways. Seed may also be sown broadcast and land harrowed with smoothing harrow. (C. A. 299)

The New Jersey Station sowed 30 pounds of seed broadcast and 15 pounds of seed with drill, and obtained practically the same yield of hay the following year—6.5 and 6.7 tons an acre respectively.[1]

216. Nurse Crop.—The sowing of a grain crop with the alfalfa is probably seldom of any advantage to the alfalfa, and may be a disadvantage when the moisture or plant food is likely to be deficient. Experience has shown that barley is a much better crop to sow with alfalfa than is oats. Barley exhausts the soil less of water and is harvested earlier than oats. Where oats is sown with alfalfa it should be sown at the rate of a bushel to the acre, and must be harvested when coming into bloom for hay. Permitting oats to stand until ripe almost always results in failure of the alfalfa, at least in humid climates. When sowing oats with alfalfa, the time of seeding should be chosen to suit the alfalfa and not to suit the oats. Alfalfa is seldom sown in the spring on wheat that was sown the previous fall, as is the general custom with clover.

Alfalfa is seldom sown with any grass or clover, although grasses are sometimes recommended where alfalfa is to be pastured, since it reduces the danger of bloating. For this purpose, brome grass probably gives the best results in subhumid sections. The Nebraska Station found that when used for pasture brome grass nearly succeeded in crowding out the alfalfa at the end of three years, when sown in equal amounts, but when used for meadow the alfalfa held its own.[2] Idaho Station reports good results for meadows with mixtures of

[1] New Jersey Sta. Rpt. 1890, pp. 156-8.

[2] Nebraska Sta. Bul. No. 84 (1904).

orchard grass and alfalfa, rye and alfalfa, and tall oat grass and alfalfa.[1] Orchard grass is considered desirable because the orchard grass is cut soon enough to prevent its becoming unpalatable, and because its habit of growth is such as to crowd the alfalfa less than other grasses. (86)

217. Weeds.—Since the first cutting of alfalfa is so early, and since the time between cutting is so short, most annual and biennial weeds common to other meadows are prevented from going to seed and are thus eradicated. Only those perennials which produce seed before the first cutting of alfalfa, like dandelion, and perennials which are more or less stoloniferous, like some of the grasses, become a serious pest in alfalfa meadows. To this, however, there are some exceptions. The wild barleys (*Hordeum jubatum* L.) and (*H. murinum* L.), which are annual grasses, are most serious weeds in alfalfa meadows in western states, as they are in other cultivated crops. This, however, is not so much due to their abundance or injury to alfalfa as it is that the barbed awns of these plants lodge in the mouths and throats of animals, producing bad sores and thus decreasing the feeding value of hay that has become infested with them.

While certain other plants of the grass family are a menace to the growth of alfalfa, alfalfa hay is usually free from weeds that are objectionable for forage purposes. Where alfalfa becomes grassy passing over the field both ways with a disk harrow, set so as not to turn the soil too much, immediately after the crop has been harvested is said to help to keep these weeds in check. Some of the weeds are destroyed while the alfalfa is stimulated. The best results with this method have been obtained on friable soils in sub-humid sections.

218. Fungous Diseases.—The most commonly distributed, and probably the most injurious, fungous disease on alfal-

[1] Idaho Sta. Bul. No. 33 (1902).

fa is the leaf-spot (*Pseudopeziza medicaginis* (Lib.) Sacc.). It is much more injurious in moist than in dry climates. The evidences of it are usually first seen in the turning yellow of the lower leaves. If these leaves are closely examined, they will be seen to contain numerous small brownish-yellow blotches in the center of which is a still smaller black circle of fruiting cups, each containing eight egg-shaped or oblong ascospores. The plant becomes infested by these ascospores floating in the air, particularly if the air is moist. The disease spreads with great rapidity, hence the desirability of mowing the crop as soon as attack begins to manifest itself. (225) Experiments with fungicides and with fertilizers at the Cornell Station gave negative results. Root-rot (*Ozonium* Sp.), a fungous disease affecting cotton and other plants, also sometimes affects alfalfa when it is grown in regions where cotton occurs.

Alfalfa leaf attacked by leaf-spot
Natural size

219. Insects.—Few insects attacking alfalfa exclusively or even chiefly have been reported. The principal insect enemy of alfalfa in the western states is the ever-present grasshopper. The remedy against grasshoppers in general is said to be deep plowing in the fall to bury the eggs and spring harrowing to destroy them. When the alfalfa field is attacked the Nevada Station recommends the use of the following mixture just after the first crop is harvested: Paris green 1, common salt 2, fresh horse dung 60 pounds. This mixture is to be scattered over the field when the hoppers are thickest, in the morning while the soil is still wet from the first irrigation.[1] By means of the hopper-dozer the Colorado Station caught in one day in a six-acre field nine bushels of grass hoppers, containing about 30,000 grasshoppers in each bushel. Winter and early spring disking of alfalfa fields will also destroy many grasshopper eggs.

220. Animals.—The pocket gopher is, in the western states, the most serious pest with which the alfalfa raiser has to contend. It destroys the alfalfa by feeding upon the roots, while the burrows seriously interfere with harvesting. Ground-squirrels, prairie dogs, and field mice are also troublesome. Many more or less successful methods of combating these pests are employed, such as poisoning with strychnine, trapping, shooting, and suffocating with bisulphide of carbon.

221. Pocket Gophers (*Geomyidae*), comprising two genera, *Geomys* and *Thomomys*, and 33 species, of which the prairie gopher (*Geomys bursarius* Shaw), also called red pocket gopher, is the most important. In color the gophers are gray, black, or brown, cinnamon or pinkish-brown prevailing; the gophers of southern Georgia, Florida and Alabama have an indistinct median stripe along the back. They are the length of a small rat, but twice as thick, have large cheek pouches opening outside the mouth, and long claws on the fore feet, adapting them to an underground burrowing life. They live singly except during the breeding season. Their natural enemies are the weasel and the gopher snake.

222. Spermophilus (meaning "seed lover"), belonging to the squirrel family (*Sciuridae*), and comprising about 73 species and sub-species in the western states, two of which are found east of the Mississippi River. The spermophiles are closely related to the chipmunks and form the connecting link between the squirrels and the marmots. The most widely distributed is the thirteen-lined spermophile (*Spermophilus tridecemlineatus* Mitchell), carrying on the back six longitudinal buff bands and seven brown bands, each of the latter containing a row of small white spots. They vary in color from gray to brown, have cheek pouches and are about the size of the pocket gopher. The chipmunk (*Tamias striatus* L.), also called ground squirrel and ground hackee, belongs to the same family (*Sciuridae*), and though it may in some instances prey on roots, its favorite food consists of nuts, berries, tomatoes, and pome fruits. A number of the *Sciuridae* consume vast quantities of destructive insects. The natural enemies of these animals are coyotes, foxes, badgers, skunks, hawks, and owls.

[1] Nevada Sta. Bul. No. 57 (1904).

223. Prairie Marmots (*Cynomys ludovicianus* Ord.), also called prairie dogs, belong to the squirrel family (*Sciuridae*), though they are much larger than the species described above. They are more closely related to the woodchuck or ground hog than to the other *Sciuridae*. They are the most gregarious of the whole family. Their natural enemies are wolves, foxes, and rattlesnakes. A spoonful of poisoned wheat placed in the mouth of each burrow is widely used to combat them.

224. Meadow Mouse (*Microtus pennsylvanicus* Ord.) and prairie meadow mouse (*M. austerus* Le Conte) are two important species of the mouse family (*Muridae*), which comprises 66 species and sub-species of continental range. They are short-eared, short-tailed, thick-set and 6 to 6.5 inches long; reddish-brown above and whitish below. They inhabit marshes, meadows, pastures, lawns, orchards, gardens, and cornfields. Their natural enemies are pickerel fish, cats, foxes, weasels, crows, marsh hawks, hen hawks, winter hawks, while they form the chief diet of owls.[1]

225. Time of Cutting for Hay.—The number of cuttings will depend on climate and soil and the stage at which it is cut, and ranges from two to five or more cuttings. Probably three cuttings are the most common. Between the 39th to the 42d parallels of latitude in the United States, the usual period is about as follows: first cutting May 25 to June 5; second cutting July 1 to 20; third cutting August 20 to October 1. It is generally thought advisable to leave a fair growth of alfalfa upon the land when it goes into winter quarters. In the sub-humid regions and in the irrigated regions the practise is to cut when the alfalfa is coming into blossom, estimated to be from one-tenth to one-third the total flowers. This is not a safe rule for humid climates. The failure in humid climates often results from a failure to cut alfalfa soon enough, particularly the first cutting. The crop should be cut as soon as the lower leaves begin to turn yellow, even though few, if any, flowers show, as is usually the case. In humid regions alfalfa is subject to spot disease, and if the plants are left to stand after the lower leaves turn yellow, in a short time most of the leaves become affected and the crop is of little value for hay. Often growers are tempted to leave an unsatisfactory growth with the

[1] In this connection, see Minnesota Sta. Bul. No. 88 (1904), pp. 144-165.

hope that it may improve, not realizing that the crop may be destroyed by disease and not realizing that the second crop cannot be obtained until the first crop has been cut. The cutting of alfalfa at just the proper time is one of the most imperative factors in alfalfa growing.

226. **Curing Alfalfa Hay.**—Alfalfa is a difficult crop to cure, especially in humid climates. Its succulent stems cure slowly and, if handled with tedder, hay rake, or other tools during the process of drying, many of the leaves fall off, reducing the weight and reducing the quality in still greater degree. The first and last cutting come at a time of year when the weather conditions are not favorable to curing any hay. Methods of curing must be practised, which will involve the least possible handling, especially after the hay has become practically cured. Winnowing by means of the clover buncher will reduce the handling. In the western states the side delivery rake is widely used, producing somewhat the same effect as the hay tedder. If teddered at all, it should be done just as soon as the alfalfa has become wilted. In humid climates it should be raked and put in cocks when quite green. The cocks are not greatly injured by rain when put up in this way and will generally cure without molding, except where the hay is in contact with the ground. The cocks must be turned or spread out and rebuilt as often as necessary to prevent molding, which will depend on the condition of the alfalfa and of the weather. In the western states where there is no danger of rainfall the alfalfa is hauled directly to the stack from windrow by means of sweep rakes, commonly called "buck rakes" or "go-devils." (39) As a preventive measure for molding, the Kansas Station recommends that the hay be stacked or stored with alternate layers of straw in the proportion of two loads of alfalfa to one of straw.[1]

227. **Alfalfa Silage.**—The difficulty of curing, especially of

[1] Kansas Sta. Bul. No. 85 (1899), p. 9.

the first and last crops, has led to silaging. The last crop, being ready to harvest at the time maize is being put into the silo, may be mixed with the latter, one load of alfalfa to two loads of maize, both being put through the feed cutter. When treated in this way, the alfalfa and maize both keep well and the mixture is well liked by cattle. While alfalfa can be preserved in the silo alone, the practise is not generally looked upon favorably, and since alfalfa silage is not more palatable than alfalfa hay, there is nothing to be gained by silaging except when curing into hay is impossible.

228. Harvesting Alfalfa Seed.—Alfalfa seed is produced principally in western Kansas, eastern Colorado, northern Utah and southern Idaho. In humid climates of the United States alfalfa produces seed sparingly, which is usually small, wrinkled and poorly developed. Even in the regions above mentioned seed is principally produced by "dry farming." If, when irrigated, too much water is applied during the time of flowering and after, the strength of the plant goes to the production of foliage rather than seed. The seed is produced usually from the second crop, and is harvested in September or as soon as the majority of the pods have turned brown. The self-rake reaper, the self-binder and the buncher are used, the former most commonly. When cured it is gathered from the piles by means of barley forks and thrown into a header box or upon a hay rack whose bottom has been covered by heavy ducking. It is then threshed directly from the load or placed in small stacks and threshed later. A regular grain separator may be used, but the huller is better. The regular clover huller may be used, but ordinarily it is modified slightly for alfalfa. As high a speed is not required to hull alfalfa seed as clover seed, and is objectionable, since the stems are more brittle and thus broken up unduly. The amount of seed produced varies according both to season and soil from 1 to 15 or even 20 bushels an acre, perhaps 2 to 6 bushels being the most common.

229. Value.—The value of alfalfa where it can be successfully grown consists in the large yield of palatable hay containing a large percentage of protein. Thus the following table based on the Twelfth Census and American analyses and digestion experiments shows the importance of alfalfa:

Comparison of Hays Grown in the United States in 1899

Hay	Acreage thousands	Total yield thousand tons	Yield per acre tons	Digestible nutrients per acre lb.	Digestible protein per acre lb.
Alfalfa . . .	2,094	5,221	2.5	2,673	609
Red clover . .	4,104	5,167	1.3	1,214	177
Cultivated grasses[1]	31,302	35,624	1.1	1,091	62

It will be seen that in 1899 there was produced in the United States about the same quantity of alfalfa hay as of red clover hay off of about one-half the area; that the yield of digestible nutrients was from two to two and a half times that of red clover, while the digestible protein an acre in alfalfa was three to four times that of red clover and about ten times that of the cultivated grasses on the basis of the composition and digestibility of timothy hay.

Since alfalfa is a perennial, it reduces the labor of caring for a given area of land to the minimum. It is not as well adapted to short rotations as clovers, since the cost of securing a seeding is greater, both because of the greater cost of the seed and, in case no nurse crop is raised, because of the loss of a crop. It requires what is recognized to be a fertile soil for staple crops and cannot, therefore, be used alone in improving worn-out soils. When grown on good soils with plenty of plant food added, its large, deep-growing roots, rich in nitrogen and minerals, leave the soil in an improved condition.

[1] Assumed for the purposes of comparison to be timothy.

230. Feeding Value.—Alfalfa hay is eaten readily by, and can be fed with good results to, horses, cattle, sheep, brood sows, and laying hens. By introducing alfalfa hay into the ration, the amount of grain necessary for milch cows and for fattening cattle and sheep may be greatly reduced. The composition and digestibility of alfalfa are quite similar to that of bran. The Tennessee Station found that one pound of wheat bran should be replaced by 1.5 pounds of alfalfa when fed to milch cows.[1] While cattle and sheep may be fattened on alfalfa hay alone, they do not on this ration get that finish which in the present markets commands the highest price. Alfalfa hay is not itself a proper ration, because of its coarseness and the large proportion of protein. Maize grain and barley meal furnish the easily digestible carbohydrates which are needed to complete the ration. Where they can be economically grown, mangel-wurzels are useful for the same reason as well as furnishing a succulent food.

The Maryland Station found that more milk was produced with a ration of alfalfa hay and seven pounds of maize meal than with maize silage and a mixture of three pounds of malt sprouts, one pound each of linseed meal, gluten meal and maize meal.[2] The Utah Station reports as the result of six tests that alfalfa-fed horses had a better appearance, and it was not so difficult to maintain their weight as when fed on timothy.[3]

Alfalfa does not stand pasturing well. While it may be used for all classes of domestic animals, it has been found preeminently useful only with swine and poultry. The danger from bloat is believed to be even greater than with red clover. It is better adapted to soiling purposes than to pasture, since regular and frequent clipping enhances its vigor and the green material can be fed without injurious results. It is especially

[1] Tennessee Sta. Bul. Vol. XVII (1904), No. 4.

[2] Maryland Sta. Bul. No. 98 (1904).

[3] Utah Sta. Bul. No. 77 (1902).

adapted to those regions in the southern states where it can be grown, both on account of the length of the growing season and because pastures of all kinds are less successful there.

231. History.—Alfalfa has probably been used for hay longer than any other cultivated plant. The ancient Greeks and Romans used it, and it is the only forage crop now extensively grown in America which was cultivated by them, except millet. It was imported into Greece from Media during the war with the Persians about 476 B. C. It was introduced into North America under the name of lucerne by the first colonists. It was tried over and over again in New England and the Atlantic states during the 150 years which elapsed prior to the Revolution. While it has been grown in Onandaga County, New York, since 1812, probably continuously, alfalfa did not attract much attention until introduced into California from the western coast of South America about the middle of the last century. In 1873 Henry Miller introduced some seed directly from Chile and sowed it upon his ranch in the San Joaquin Valley. Subsequently the firm of Miller and Lux grazed over 100,000 head of cattle and more than that number of sheep on alfalfa pasture in the summer and fed them alfalfa hay in the winter. From this object lesson of the great value of alfalfa has spread the present culture of it in the United States.

II. SAND LUCERNE

232. SAND LUCERNE (*Medicago media* Pers.) closely resembles alfalfa in appearance, habit of growth, and nutritive qualities. (196) It may be distinguished from alfalfa by its more spreading habit, by its flowers ranging from purple to lemon-yellow with many intermediate shades, and by its pods, which are in about three-fourths of one coil instead of two to four coils as in alfalfa. The seeds are about four-fifths the size of alfalfa seeds. The Michigan Station reports that sand lucerne is able to withstand the severe winters of the Michigan climate, while alfalfa is easily killed. On a dry, sandy plat of soil the average yield during four years at the Michigan Station was at the rate of over five tons of cured hay per acre.[1] Three and four

[1] Michigan Sta. Bul. No. 198 (1902), p. 150.

cuttings a season were obtained. Thus far only imported seed is to be had. Attempts to produce seed in Michigan have proved unsuccessful. Sowing alone in early May at the rate of 15 pounds of seed an acre is recommended.

233. Collateral Reading.—F. D. Coburn: The Book of Alfalfa, p. 336. New York: Orange Judd Co., 1906.

Thomas Shaw: Clovers and How to Grow Them, pp. 114-193; 333-7. New York: Orange Judd Co., 1906.

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R. Harcourt: Lucerne or Alfalfa. Ontario Agr. Col. Bul. No. 111, 1900.

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Geo. L. Clothier: Alfalfa. In Kansas State Bd. Agr. Report (March, 1900), pp. 7-41.

S. J. Hunter: Alfalfa Culture and Insect Life. In Kansas State Bd. Agr. Report (March, 1900), pp. 41-51.

J. L. Stone et al.: Alfalfa. New York Cornell Station Bul. No. 237 (1906), pp. 141-171.

Andrew M. Soule and Meade Ferguson: The Inoculation and Cultivation of Alfalfa. Virginia Station Bul. Vol. XIII (1905), No. 5.

XI

LEGUMINOUS FORAGE CROPS

1. BLACK MEDIC

234. Description.—Black medic or yellow trefoil (*Medicago lupulina* L.) is in appearance similar to alfalfa, but is smaller in all its parts. Its stems are spreading, four inches to two feet in length, and, unless grown with other crops, seldom reaching above nine to twelve inches high. It bears small roundish heads of yellow flowers, which, as they ripen, become a spike-like cluster of almost jet black, one-seeded, somewhat kidney-shaped, strongly veined pods. These pods, with the calyx persisting, easily fall off, but the pods do not open readily, hence black medic seed is quite likely to contain seeds in which the very characteristic pods have not been removed. Black medic begins to flower in May and, if not cut, will continue for a couple of months, the lower flower clusters becoming fully ripe while the upper ones are still forming. The tap root grows about a foot in depth; otherwise it is similar to alfalfa, only smaller.

Black medic, showing mature clusters of seeds. About one-half natural size. From photo taken June 28 in central New York.

The plant is sometimes confused with yellow suckling clover (*Trifolium filiforme* L.) and hop clover (*T. procumbens* L.), both of which have small heads of yellow flowers. Both may be distinguished by the fact that their leaflets arise from the end of the leaf stalk, *palmate,* while in black medic the lateral leaves arise on the sides of the leaf stalk, *pinnate.* Moreover, in these clovers, as in other clovers, the corolla is persistent, its withered remains enveloping the pod.

235. Adaptation.—The plant is grown somewhat extensively in the cooler countries of Europe, but has never been generally used in North America. It has attracted attention here chiefly by reason of the use of imported seed to adulterate alfalfa and red clover. It is adapted to the same soils as red clover and has a climatic adaptation similar to that of alsike clover. In other words, it does best on limestone friable soils in a cool, moist climate. It will, however, remain green during summer droughts, and has for this reason been recommended for lawn mixtures, probably unwisely. On account of its small yield and habit of growth, it is adapted only to pasture. Even for this purpose, it is not equal to white clover. The evidence seems to be that it is palatable and nutritious and, in suitable climates and on suitable soils, where clovers fail it may be worthy of trial. It may be described as a weak biennial. It has almost the habit of an annual, in that under suitable conditions it makes its chief growth the first season and usually dies after the first cutting the second year. It seeds so abundantly, however, that its growth is practically permanent.

236. Seed.—The cheapness of the seed, which is one of the factors to cause it to be cultivated in Europe, has also caused it to be used as an adulterant. The seeds are about the same size and shape as the smaller and more oval seeds of alfalfa (325,000 per pound). They are to be distinguished by the more regular, globular form and the more prominent projecting tip of the radicle. The larger seeds of alfalfa are more kidney-shaped, and all alfalfa seeds are flattened and have a tendency to be angular, while the black medic seeds are distinctly circular and are uniform in shape, size and color (yellowish-green). (200) They are sufficiently distinct from red clover seeds in color and form to be detected readily. (150)

Black medic (yellow trefoil). Pod on the left; single seed on the right. Enlarged four times.

237. Seeding.—The power of germination is similar to that of alfalfa. It usually contains few impurities and is not adulterated. If sown alone, 15 to 20 pounds of seed per acre are required. Black medic seed is sometimes sown in the pods, when about twice the amount by weight is required. It should, however, be sown only in mixtures in about the same proportion and under the same conditions as white clover.

II. BUR CLOVERS

238. Bur Clovers.—(*Medicago maculata* Willd. and *M. denticulata* Willd.), which more properly should be known as spotted medic and toothed medic, respectively, derive their names from the spirally twisted, conspicuous pods whose edges are armed with one or two rows of prickles. In the toothed medic these prickles end in a distinct hook. These pods or burs cause trouble by getting into the wool of sheep. (201) In spotted medic there are one or more dark spots near the center of each leaflet. The plants have a general likeness to alfalfa, but are more spreading.

The bur clovers are annuals, native to the Mediterranean region. Toothed medic has become widely distributed in California and somewhat in the southern states, where it is considered valuable for pasture and for the improvement of the soil. Spotted medic is probably less widely grown in California, but has been grown somewhat more extensively in the southern states than the toothed medic. It grows only in mild climates. It is sown in the fall and ripens the following spring. Another crop may be grown on the same land during the summer. The seed left in the soil will produce a crop during the succeeding winter months. It is sometimes sown in maize and cotton to provide winter grazing and to enrich the soil.

The seeds closely resemble those of alfalfa, but are larger, dull, and distinctly kidney-shaped. In the seeds of spotted medic the tip of the radicle projects prominently and is often tinted red.[1] Somewhat less seed per acre is required because of its annual habit. The seed is often sown in the bur, when 30 to 60 pounds per acre are used. The burs are obtained by raking off the dead stems or vines, and sweeping up the remaining burs with a wire broom. As much as 1,000 pounds of such burs are said to have been obtained from an acre.[2] Where seed is scarce a few seed may be placed in hills three feet apart: otherwise, sow broadcast by hand and harrow.

III. JAPAN CLOVER

239. Japan Clover or lespedeza (*Lespedeza striata* (Thunb.) Hook and Arn.) belongs to a tribe (*Hedysareae*) which is characterized by the fruit not being a true legume, the pod being divided crosswise by one or more joints, *loment*. In the genus *Lespedeza* there is one or at most two joints. The leaves have three leaflets, the lateral leaflets being on the side of the leaf stalk, *pinnate*. There are about a dozen native perennial species more or less widely distributed throughout the United States, especially southward, some of which, occurring in the herbage, add to its value.

Japan clover is an annual of eastern Asiatic origin, introduced from China into the South Atlantic states about 1850, and said to have been widely distributed during the war between

[1] Stebler and Schröter: The Best Forage Plants, p. 153.

[2] Thomas Shaw: Clovers and How to Grow Them, p. 298.

the states, the seed having been carried from place to place by the hay and the horses. It is now naturalized as far west as Texas.

It is a spreading or ascending plant with one to three sessile or nearly sessile pink or purple flowers, usually from 6 to 12 inches high, but on rich lowlands sometimes 30 inches or more, when it may be cut for hay. Ordinarily, however, it is used for pasture, and takes somewhat the same place in the south as white clover does in the north. While Bermuda grass and Japan clover are to the southern states what Kentucky blue grass and white clover are to the northeastern states, yet they have been much less extensively cultivated.

Japan clover seed. Seed enclosed in the pod on the left; naked seed on the right. Enlarged four times.

Japan clover is adapted chiefly to the Gulf states, where it will grow on a variety of soils. It is killed by frost and suspends growth during summer droughts, consequently its chief pasture is furnished in spring or fall. It re-seeds on the same ground year after year, and like white clover is not sown much artificially. The seeds are rounded to egg-shaped, 0.05 to 0.07 inch long and 0.04 to 0.06 inch wide; green, greenish brown, amber, or black. They usually occur commercially in the pod which in turn is enclosed in the calyx, as shown in the illustration. The rate of seeding is about one-half bushel of unclean seed per acre.

IV. VETCHES

240. Kinds.—There is at least a score of either introduced or native species of vetch, two of which have been cultivated in this country: spring vetch or tare (*Vicia sativa* L.) and winter, hairy, or sand vetch (*V. villosa* Roth.). The former is widely used in England as a soiling crop for milch cows. It makes an excellent food because palatable and containing a remarkably high proportion of digestible protein, but has not been found adapted to any considerable portion of the United States,

Hairy vetch taken at Cornell Station June 28. Vine in bloom
One-fifth natural size

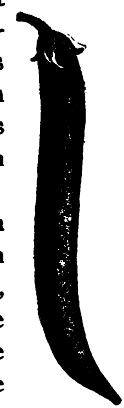
although it has been grown somewhat in the New England states and in Washington and Oregon.

Winter vetch is likely to find a much wider adaptation in the United States, although always as a secondary crop, and is the species which will be described here.

241. Description.—Winter vetch is a winter annual with vine-like, trailing, sparingly branched stems three to five, sometimes eight, feet long, bearing leaves with about eight pairs of leaflets, an upper pair of tendrils and the midrib terminating in a tendril. From one to two dozen bluish-purple flowers are borne in racemes from the axils of the leaves. Three to six of the flowers on each flower stalk produce pods one inch to one and a half inches long and three-eighths to one-half inch wide, in which are about six brown to black, round to lens-shaped seeds variable in size, but averaging about one-sixth of an inch in diameter. When grown unsupported the stems grow erect for about one foot, but as the plant increases in length it becomes successively more and more decumbent, so that when it is four feet in length, three feet may be trailing upon the ground. The vegetative portion of the plant, especially the newer growth, is quite hairy, but this does not prevent it from being relished by domestic animals. It produces a mass of fibrous roots bearing an abundance of root-tubercles. Seed sown at the Cornell Station on July 10 produced plants whose roots on November 1 were traced to a depth of 3 feet 8 inches in a tough, impervious clay.[1]

Winter vetch pod Natural size

It is readily distinguished from the spring vetch by the difference in the pods. In the spring vetch the pods are less than a quarter of an inch wide, from one and a half to two inches long, and are usually black instead of straw-colored, as in the winter vetch. The pods are about 8-seeded. The seeds are about the same size as those of winter vetch, but are blacker.



Spring vetch pod Natural size

242. Adaptation and Value.—Although it will grow better upon good than upon poor soil, winter vetch is especially adapted in the farm economy as a winter or cover crop for the improvement of poor sandy or gravelly soils. It is char-

[1] New York Cornell Sta. Bul. No. 198 (1902), p. 110.

acterized not only by the abundance of the root-tubercles, but by the fresh and apparently active root-tubercles very early in the spring or during open weather in the winter, in which it differs from most other commonly cultivated legumes. It is believed, therefore, that vetch is unusually active during this period in gathering the free nitrogen of the air.

The importance of the root-tubercles was shown by the Alabama Station, where in field trials the yield of field-cured hay was at the rate of 232 pounds per acre without inoculation and 2,540 pounds with inoculation.[1] Inoculation was accomplished by dipping the seed in water into which there had been stirred and allowed to settle earth, in which spring vetch had for several years in succession made a thrifty growth. Because of its habit of growth, it is not likely to be raised extensively for forage, but it is highly recommended by the Alabama and Mississippi stations "to furnish winter grazing upon Bermuda grass sod."[2] At the Cornell Station three months' growth of hairy vetch produced 6,824 pounds of air-dried forage per acre, containing 240 pounds nitrogen, 53 pounds phosphoric acid and 52 pounds potash, while during the same period cowpeas produced 2,262 pounds of forage per acre, containing 46, 23, and 19 pounds respectively.[3] It appears perfectly hardy in central New York and to do well as far south as Mississippi. It resists drought well, but is not adapted to land containing an excess of water.

243. Culture.—While it can be sown in the spring, it is valuable principally as an early fall-sown crop. It may be sown alone at the rate of from one to one and a half bushels (60 to 90 pounds) per acre. Sowing it with rye is recommended, as the rye helps to support the vetch, makes it more easily harvested, if this is desired, and adds to the vegetable

[1] Alabama Sta. Bul. No. 87 (1897), p. 464.

[2] Ibid.

[3] New York Cornell Sta. Bul. No. 198 (1902), p. 108.

growth in case it is plowed under. The New York State Station reports satisfactory results with one and a half bushels of vetch and one-half bushel of rye. Others prefer one-half to one bushel of vetch and one bushel of rye, on the ground that if too much seed is sown the rye will not be able to support it. The rye and vetch seed are mixed and sown in the ordinary grain drill. The vetch starts rather slowly and should therefore be sown quite early. In northern latitudes it may be sown as early as August 1, and should not be sown later than October 1. The high price of seed has prevented the use of winter vetch as a renovating crop.

Seed is said to germinate poorly after it is two years old. When it is the plan to sow vetch regularly each season, one should arrange to grow the seed. The seed is produced rather abundantly. One load of ripened vetch may produce six bushels of seed. It may be threshed in the ordinary threshing machine. Annual crops have been obtained at the Mississippi Station during 12 years by self-seeding.[1]

V. VELVET BEAN

244. Velvet Bean (*Mucuna utilis* Wallich.) in favorable localities produces vines 30 to 50 feet in length. The purple flowers, borne in clusters at intervals of two or three feet at the joints of the stem, produce short, cylindrical pods, covered with black, velvety down. At the Kentucky Station, pods were produced which measured two and a half inches in length and one-half inch in diameter, but no seeds were borne. Each pod contains three to six large, rounded, brown and white mottled seeds, and is constricted laterally between the seeds and often more or less curved. The seed is about one-half inch in length; a protruding lip characterizes the scar.

[1] U. S. Dept. Agr., Div. Agros. Bul. No. 2 (Revised), p. 75.

Its climatic range in North America is confined to that of the cotton plant. In sections where seed will ripen, the plant compares favorably with the cowpeas as a soil "renovator." The method of culture resembles the latter, except that rows are usually farther apart—four to five feet. It finds its best growth

Velvet bean flowers. One-third natural size. *a* **and** *b* **Single flowers at different stages (From photo by Garman)**

A cluster of velvet bean pods One-third natural size (From photo by Garman)

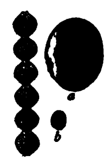
on light sandy soils with liberal applications of acid phosphate and potash. Seed may be broadcasted at the rate of one bushel per acre, or planted at intervals of two feet in rows four feet apart, dropping two to three seeds in a hill. It has been reported to yield 2 to 4 tons of hay and 20 to 28 bushels of seed per acre.

The plant is apparently a native of India whence, as an ornamental garden plant, it was introduced into the United States in the latter half of the nineteenth century. Its use as a forage plant is yet in the experimental stage.

VI. FLORIDA BEGGAR WEED

245. Florida Beggar Weed (*Desmodium tortuosum* D. C.) is an annual, closely related to Japan clover, from which it differs in having its pods several jointed and in its much larger size, growing under cultivation in the tropics six to ten feet high. It is adapted to the sub-tropical portions of Florida and the Gulf states, especially on rich, moist, sandy lands. Horses, mules and cattle eat it readily when green or cured into hay. If, however, it is sown thinly, it becomes woody and is less desirable. Not less than five pounds of clean seed per acre should be sown. Seeding is usually done in the latter part of June.

Florida beggar weed spray, showing flowers in bloom.



Florida beggar weed seed. *a* Enlarged four times; *b* natural size. Loment to the left, natural size.

VII. LOTUS

246. General Characters.—There are 120 species of the genus *Lotus* widely distributed, of which about 40 occur principally in western United States. Of these, three have been cultivated in this country: bird's-foot trefoil (*Lotus corniculatus* L.), prairie bird's-foot trefoil (*L. americanus* (Nutt.) Bisch.) and square pod or winged pea (*L. tetragonolobus* L.). These are plants having somewhat the appearance and habit of growth of black medic, but have larger flowers, and produce straight, oblong, many-seeded pods. The basal leaflets have often been mistaken for stipules, which are rudimentary. They are characterized by growing in the driest situations and upon the lightest and most sterile soils.

247. Bird's-foot Trefoil.—The branching leafy stems are 6 to 18 inches long, angular, and are spreading or ascending. The tap root is spindle-shaped and relatively large, penetrating to a moderate depth. There are two to six yellow flowers in each cluster, the standard being tinged with red and green. The pods are 1 to 1.5 inches long. The seeds, about the size of red clover seeds, are oval, flattened on the sides, brown with a wide, round spot at the hilum. In Europe there are three varieties: common, slender or fine-leafed, and hairy bird's-foot trefoil. Commercial seed is usually of the slender or

fine-leaved variety. The seed is often adulterated with marsh bird's-foot trefoil (*L. uliginosus* Schk.), because it is cheaper; it has no agricultural value, except on marshy or moor land. The seeds are less than one-half the size by weight and are olive-green.

Florida beggar weed; the young plant

Bird's-foot trefoil has become naturalized in this country, especially in the south.[1] It is cultivated somewhat widely, although perhaps not extensively in Europe.

"By itself, bird's-foot trefoil is not productive, but it is very suitable, in mixture with fodder plants of taller growth, for filling up the spaces beneath and between them; in this way, it materially adds to the produce. It is suitable either for cutting, or depasturing. It thrives almost on any soil, and is perennial. These properties render bird's-foot trefoil a very valuable plant for permanent pastures and meadows. It is also appropriate for shorter leys, where red clover does not thrive. The great obstacle to its cultivation is the very high price of the seed."[2]

It is recommended to be sown in the spring with a nurse crop at the rate of 11 pounds of seed per acre.

248. Prairie Bird's-foot Trefoil is a native annual, erect species occurring in the High Plains region from New Mexico to North Dakota, and also on the Pacific coast. "This vetch often grows two to three feet high in good soils and seasons, or may not be more than a few inches high during dry seasons or on sterile soils, but it roots deeply and is well adapted to its native prairies. The seed may be had for the gathering, and need not cost any more than clover or alfalfa, if the trouble is taken to run the chaff through a fanning mill."[3]

249. Square Pod Pea is a much-branched, ascending annual, native to southern Europe. The California Station produced on two plats yields at the rate of 24 and 26 tons of green material, equivalent to four or five tons of

[1] U. S. Dept. Agr., Div. Agros. Bul. No. 2 (Revised), p. 40.

[2] Stebler and Schröter: The Best Forage Plants, p. 161.

[3] U. S. Dept. Agr., Div. Agros. Bul. No. 2 (Revised), p. 40, 1900.

cured hay per acre. In California, when sown in January, it will be ready to plow under in May. While it has been found to do fairly well on heavy soils in that state, the scarcity of the seed and the relatively limited adaptation of the plant insure it little promise.

VIII. WHITE AND YELLOW MELILOTUS

250. WHITE AND YELLOW MELILOTUS (*Melilotus alba* L. and *M. officinalis* L.), usually known as sweet clovers because of their characteristic odor, are distinguished from alfalfa, for which they are not infrequently mistaken, by their ranker growth, more succulent structure, smoother surface, rather more distinctly toothed leaves, their long racemes of white or yellow flowers and their odor of coumarin. In many parts of the United States it is the common wayside weed, the white and earlier blooming melilotus being the more frequent. The seed cf the white species has been sold under the name of Bokhara clover, or simply sweet clover, for forage purposes. It is, however, exceedingly distasteful, either green or cured, to all classes of domestic animals, and hence unfit for forage.

The Illinois Station has shown that the bacteria in the root-tubercles of the melilotus readily produce root-tubercles on alfalfa. It has, also, been held in the North Atlantic states that the occurrence of these weeds on a given soil is an indication that it is adapted to the growth of alfalfa. It probably has a much wider range of soil and climate than alfalfa. Because of its rank growth and nitrogen-gathering propensities, it has been recommended for the renovation of extremely poor soils. The difficulty of eradicating it is in many instances an objection to such use. It is considered an excellent food for bees. The seed sometimes occurs in alfalfa. The seeds have a bitter-sweet taste and the characteristic odor of sweet clover.

"The seed of the Bokhara clover averages darker than that of alfalfa. While the sizes of individual seeds of the two kinds are similar, the form of Bokhara seeds is more constantly oval, with the scar nearer one extremity, and the tip of the caulicle never projecting. They are relatively thicker, not curved sidewise, and the surface is often finely uneven. Furthermore, an examination of the embryo shows the longer caulicle of Bokhara to be often abruptly bent, forming an extra segment. Nevertheless, the general likeness between the two kinds of seeds is very striking, and only careful examination will expose the deception before the seed is sown. The presence of pods of Bokhara is good evidence of adulteration. The assurance of a western seed firm that its alfalfa seed contained no sweet clover or dodder, which recently came to the notice of the writer, was at least suggestive, particularly as dodder seeds were present in considerable number." [1]

[1] Nevada Sta. Bul. No. 47 (1900), p. 9.

IX. SAINFOIN

251. Sainfoin or esparsette (*Onobrychis sativa* Link.) is an erect, leafy perennial one to two feet high, bearing from the axils of the leaves clusters of many bright rose-red flowers in spike-like racemes on long flower stalks. Its roots are said to penetrate two to three times as deeply as alfalfa roots. (130) There are six to twelve pairs of lateral leaflets with an odd terminal one, *imparipinnate.* The one-seeded, compressed, reddish-brown pods, about one-fourth inch in the longest diameter, do not open readily. The upper margin of the pod is straight and thick; the lower thin and curved with sharp teeth. The seeds are kidney-shaped with the radicle one-third the length of the seed. There are about 22,500 seeds to the pound. The power of germination, which they lose after one year, is generally rather low.

In Europe it has been possible, by the cultivation of sainfoin, "to utilize large tracts of land which formerly were almost valueless. It is the most important fodder plant for dry and barren calcareous hills. It withstands extreme drought, thrives without manure, and is of long duration. It is not rare to see fields of sainfoin 20 years old which, even now, are doing well."[1] While it thrives in the older parts of Germany, it is suited to temperate rather than to cold climates. Young plants are liable to be killed in the winter if not protected. Old sainfoin is little affected by the winter, but wet and cold summers diminish the yield and kill some of the plants. It has been widely tested by the stations of the United States without as yet having been found to have any adaptation to American conditions. Where it can be grown it has the same place in the agricultural economy as alfalfa, which it resembles in methods of culture and harvesting. The seed is usually sown in the pods, Stebler recommending 78 pounds per acre or half this amount if hulled seed. It is usually sown without a nurse crop, and is rarely mixed with grasses or other legumes.

X. KIDNEY VETCH

252. Kidney Vetch (*Anthyllis vulneraria* L.) is a perennial, having erect or spreading stems 8 to 16 inches long with comparatively little foliage. The yellow flowers are borne in rather large clusters. The side leaflets consist of one or more pairs or may, on the basal leaves, be entirely absent, while the odd and terminal leaflet is much larger. The one-seeded pod is about one-fourth inch long and is enclosed in the persistent calyx, which acts as a seed distributer. The seeds are somewhat oval, not unlike black medic in form, but larger and mottled with yellow and green. There are about 150,000 seeds to the pound.

This plant was brought into cultivation in northern Germany about the middle of the last century on sandy or calcareous soils too light to grow red clover. It is but little affected by drought or by cold. It may, therefore, be sown in the fall with rye at the rate of 15 to 20 pounds of seed per acre.

[1] Stebler and Schröter: The Best Forage Plants, p. 95.

It is recommended by Stebler as especially suited to mixtures with grasses and clovers whether for pasture or for hay. Usually there is but one cutting a season, a little later than red clover, the aftermath being small. The yield is not large, but is considered sure. In Europe it is deemed especially valuable in ameliorating the soil. In America it has not been found to be sufficiently valuable to establish itself as a cultivated crop.

Practicums

253. Outline for Discussion of Leguminous Forage Crops (for general references see 111).—Take for material red clover, alsike clover, white clover, alfalfa, and cowpeas.

Description: I, 18[1]; V, 482; VII, 115; XI, 28; XIV, 241; XVI, 1066; XVII, 23, 242.

Acquirement of nitrogen: IV, 14; X, 119; XIV, 563; XV, 227; XVI, 748, 850, 954; XVII, 133. See Rothamsted Experiments for Fifty Years, pp. 164-6. (132, 143.)

Adaptation and distribution: III, 398; IV, 139; XI, 28; XV, 665; XVI, 39; XVII, 26, 239, 1056, 1059. See Twelfth Census, Vol. VI.

Seed: V, 399; VI, 430; XII, 959; XV, 1084; XVI, 660; XVII, 241, 547, 857, 1148, 1149. See Wallace's Farmer, Feb. 25, 1906, p. 255; March 2, 1906, p. 294.

Cultural Methods: General: II, 200; XV, 237, 730; XVII, 25, 129, 242, 354, 355, 856, 857, 1059.

Fertilizers: III, 293; XI, 530; XIV, 428; XV, 139, 346; XVII, 1141.

Liming: XII, 625; XV, 464; XVII, 857, 1059, 1148.

Rotation: XII, 625; XVI, 150; XVII, 356, 1141.

Harvesting and storing: IX, 439; XIII, 548, 901; XVII, 25, 1059.

Value: Feeding value: III, 512; IV, 736; VIII, 1008; X, 676; XI, 570; XIII, 270, 271; XIV, 605; XV, 177, 899; XVI, 82-85; XVII, 25, 380, 491, 579, 686, 688, 856, 897, 900, 1179.

Value as cover crop for green manure: IV, 208; V, 699, 776, 874; X, 252; XVII, 354.

254. Leguminous Forage Plants.[2]—Give each student a specimen of six legumes of which the following are suggested: red clover, alsike clover, alfalfa, black medic, sweet clover, hairy vetch.

Leaves: spirally arranged; two-rowed: abundant; medium; not abundant.

Leaflets: No. ....; palmate; pinnate: smooth; hairy: edges smooth; serrated.

Leaflets: Sketch.

Stipules: attached to petioles; not attached to petioles.

[1] The Roman character refers to Experiment Station Record volume; the Arabic to the page.

[2] This practicum is best conducted with fresh specimens, although dried or mounted specimens may be used. (110)

Stems: height ....; diameter one inch from base ....; erect; spreading; decumbent; trailing.

Stems: round; square: hairy; smooth: stoloniferous; not stoloniferous.

Branches: none; few; many.

Inflorescence: at end of leaf-bearing stem or branch; springing from axil of leaf.

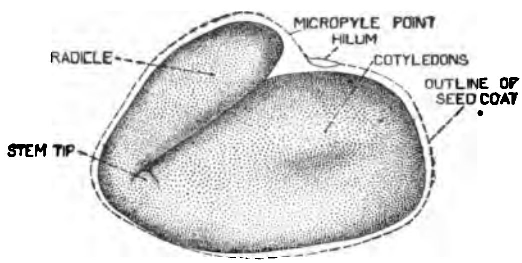
Inflorescence: raceme; umbel; capitulum.

Flowers upon maturity: reflexed; not reflexed.

Calyx: length of anterior tooth compared with other teeth..........

Petals: united; free: white; red; pink; purple; blue; yellow: persistent; not persistent.

255. Identification of Leguminous Forage Plants.—Select and preserve the whole fruit of a number of the leguminous forage plants and of those



Sweet clover (*Melilotus alba*) seed showing relation of the embryo to the seed coat
Enlarged twenty-five times
(Redrawn from Roberts)

leguminous plants which are likely to occur as impurities or adulterants. The following are suggested: red clover, alsike clover, white clover, alfalfa, black medic, sweet clover, hairy vetch. The following outline suggests qualities which might be observed. Where adjectives used do not apply, others may be used. The practicum on beans should precede this practicum.

Calyx: no. of teeth ....; relative length of inferior tooth ....

Calyx tube: hairy; smooth; no. of ribs..........

Corolla: no. of petals..........; free; united; persistent: easily removed: smooth; hairy.

Pod: roundish; kidney-shaped; elongated: straight; twisted: opens longitudinally; opens transversely.

Style: persistent; deciduous.

Seeds per pod: extreme nos..........; usual no..........

Threshing: seeds easily removed; seeds difficult to remove; reason.

Seed: viewed from two largest diameters: round; oval; elliptical; kidney-shaped.

Seed: viewed from two smallest diameters: round; oval; flat.

Seed: length of largest diameter..........; second largest diameter........

Seed: orange; yellowish-brown; dark olive-green; black; yellow; reddish; red; green; yellowish-green.

Hilum: round; oval; elongated.

Radicle: more than half the edge; half the edge; less than half the edge.

Radicle: tip prominent; tip not prominent.

256. For the Identification of the Seeds of Clovers and their Common Impurities and Adulterants.—This practicum should be preceded by the practicum on the fruits of leguminous forage plants. Give each student two grams of clover seeds and impurities mixed in definite proportions. The following is suggested as satisfactory: red clover 60 per cent.; alsike clover 20 per cent.; white clover 10 per cent.; black medic, sweet clover, and timothy, 2 per cent. each; and 0.5 per cent. each of lady's thumb (*Polygonum persicaria* L.), Rugel's broad plantain (*Plantago rugelii* D. C.), narrow plantain (*Plantago lanceolata* L.), sorrel (*Rumex acetosella* L.), curled dock (*Rumex crispus* L.), yellow foxtail (*Chaetochloa glauca* (L.) Scribn.), ragweed (*Ambrosia artemisiaefolia* L.) and witch grass (*Panicum capillare* L.).

The student should be required to separate these seeds and, if practicable, as a check on the accuracy of his work, to obtain the weight of each. Named samples of the seeds of each may then be examined by the student and his own sample named therefrom. Mounted specimens of each plant should also be on exhibition. If students are not supplied with hand lens, samples mounted under a good reading glass or similar microscope may be provided.

257. For the Identification of Alfalfa Seed and its Common Impurities and Adulterants.—This practicum should be preceded by the practicum on the fruits of leguminous forage plants. Give each student two grams of alfalfa seed mixed with definite proportions of other seeds. The following is suggested as satisfactory: alfalfa 50 per cent.; black medic 40 per cent.; sweet clover, bur clover, 2 per cent. each; and 1 per cent. each of field or large seeded dodder, clover or small seeded dodder, lamb's quarters, green foxtail, wild mustard, and dandelion. The practicum may be conducted as in 256.

258. Field Study of Alfalfa.—The following is suggested as a possible practicum at any institution where experiments in alfalfa are being conducted, the outline to be changed to suit conditions:

I. (a) Observe stand and presence of weeds on 3-year seeding.
   (b) Observe stand and presence of weeds on 5-year seeding.
   (c) Observe stand and presence of weeds on 6-year seeding.
   (d) Note the nature and habit of dodder.
   (e) What is the effect of its presence in the field?
   (f) How does alfalfa renew its growth?

II. Observe the stand, degree of browsing, and presence of weeds on the experiment pasture.

III. (a) Study and make diagram of the lay-out and treatment of plats 741-750 on the Mitchell Farm.

(b) Note the stand on

1. limed portion;
2. unlimed portion of each plat.

(c) Note the abundance of weeds and grass (also clover) on

1. limed portion;
2. unlimed portion of each plat.

Remarks as to nature of soil, inoculation, and condition of growth.

259. Collateral Reading.—F. G. Stebler and C. Schröter: The Best Forage Plants, pp. 156-164. London: David Nutt, 1889.

Thomas Shaw: Clovers and How to Grow Them, pp. 291-332; 338-344. New York: Orange Judd Co., 1906.

F. Lamson-Scribner: Southern Forage Plants. U. S. Dept. Agr., Farmers' Bul. No. 102 (1899), pp. 31-3; 38; 41-5.

Jared G. Smith: The Cultivated Vetches. U. S. Dept. Agr., Div. Agros. Circ. No. 6, 1898.

Jared G. Smith: Florida Beggar Weed. U. S. Dept. Agr., Div. Agros. Circ. No 13, 1899.

J. B. Killebrew: Grasses and Forage Plants. Tennessee Station Bul. Vol. XI (1898), Nos. 2, 3, and 4; pp. 87; 89; 90; 104-8.

J. F. Duggar: Winter Pasturage, Hay, and Fertility Afforded by Hairy Vetch. Alabama Station Bul. No. 105 (1899), pp. 129-160.

XII

LEGUMES FOR SEED

260. Kinds.—The most extensively grown legumes for their seed are the common, kidney or haricot bean (*Phaseolus vulgaris* L.), the common pea (*Pisum sativum* L.), and the peanut (*Arachis hypogaea* L.). In addition to these the cowpea (*Vigna catjang* Walp.) and the soy bean (*Glycine hispida* Maxim.), although more extensively cultivated for their forage, are also cultivated for their seeds for human consumption, although more largely for domestic animals. The broad or horse bean (*Vicia faba* L.) common in England and well known to ancient agriculture, is sparingly raised in Canada for its seeds and forage for domestic animals. The hot summers of most portions of the United States are not suited to its growth. Others grown in gardens for human consumption, but rarely raised under field conditions, are lima bean (*Phaseolus lunatus* L.), Spanish bean or scarlet runner (*P. multiflorus* Willd.), black bean (*Dolichos labab* L.), and two varieties, Yard Long and Cuban—sometimes called Cuban asparagus or simply asparagus bean—(*D. sesquipedalis* L.). All legumes cultivated for their seeds are annuals.

I. FIELD BEANS

261. Relationships.—The plants of five genera, *Phaseolus, Dolichos, Glycine, Vicia* and *Vigna,* and occasionally some others, are regarded as beans, or at least have some species that are so regarded. While it is a common expression that one does not know much if one does not know beans, it is difficult to state any characters that are common to all beans.

Generally beans are more or less vine-like plants, although some of the uncultivated forms have acquired the bush or so-called dwarf habit of growth. Soy beans, however, are upright plants without any tendency to climb, and the broad or horse bean, although belonging to a genus whose species are mostly vines or vine-like, is an erect growing plant. Bean plants are usually coarse growing and harsh, with relatively large leaflets and rather woody stems. The cowpea is the least harsh and woody.

Beans may be grown (1) for the whole plant for forage; (2) for the ripened seed; (3) for the unripened seed, when they are known as shell beans; and (4) for the young pods, when they are known as string or snap beans. As a rule, only broad or horse beans, soy beans, and cowpeas are raised for forage. The plants of the genus *Phaseolus*—namely, common or kidney bean, lima bean, and Spanish bean—are not highly esteemed for forage. Lima beans, black beans, soy beans, cowpeas, and horse beans are used for human consumption only as shell or ripe beans; common beans and Spanish beans as either snap, shell or ripe; and Yard Long and Cuban only as snap beans. The common bean and the lima bean may be grown either as a bush or dwarf variety, or as a climbing or pole variety, without reference to the use for which they are to be employed. When grown as snap beans, either common or lima beans, whether bush or climbing, may have either green or yellow pods; when the latter, they are known as wax beans.

What are known as field beans are bush varieties of the common or kidney bean grown for their ripened seeds. These are in no way botanically distinguishable from the green pod bush varieties grown as shell or as snap beans. The field varieties may be used as snap or as shell beans, while the garden varieties may be grown under field conditions for their ripened seeds. The latter practise is rare. In general, the field varieties are more hardy than the garden varieties; that is, they will thrive under more adverse conditions, and are, perhaps, less subject to disease. The pods are usually less fleshy, the strings more pronounced (they are entirely absent in some garden varieties), and the seeds more abundant and better developed.

262. Common Characters.—Field beans have upright, branching, ribbed stems bearing large leaves with three entire oval-acuminate leaflets, the upper ones symmetrical, the lateral ones oblique. There are two stipules at the base of the upper leaflets and one at the base of each of the lateral leaflets. The flowers are borne in racemes from the axils of the leaves. A pair of flowers and the pods arise at a single place, and are borne on short stalks, pointing in opposite directions. The calyx is small compared with the corolla. The pod is linear and several-seeded; it is not jointed, but may be slightly constricted between the seeds.

263. Variable Characters.—The plant may vary in height, usually from 24 to 30 inches; it may be upright or spreading; it may have runners—that is, show a tendency to climb; or runners may be wanting. The leaves vary abundantly; the leaflets vary in size, shape, texture, and color. The flowers may be white or purple. The flower or pod stem varies in length and in number of pods. The pods may vary in length and in number of seeds; they may be straight or curved, twisted or symmetrical, flat or oval, smooth or rough, depressed or full between seeds. The seeds may be white, brown, red, black, or mottled. The scar or eye (hilum) may be white, black, yellow or mottled yellow. The seed varies greatly in shape and size.

264. Varieties.—While the common bean is known as kidney bean, certain varieties of the kidney bean are known as kidney beans, because of their kidney shape; while other varieties are rather loosely classified as marrow, medium, or pea beans. The last two types are often called navy beans. Gilmore has studied at Cornell University the varieties of field beans. He proposes the following key:

Seed 0.6 inch or more in length, more or less reniform. Ratio, length, width, thickness = 0.4 : 0.19 : 0.15 — Kidney

Seed between 0.4 and 0.6 inch in length. Thickness exceeding half of the length. Ratio, length, width, thickness = 0.4: 0.26: 0.24 — Marrow

Seed 0.4 to 0.48 inch in length. Thickness less than half of the length. Ratio, length, width, thickness = 0.4 : 0.27 : 0.20 — Medium

Seed 0.3 inch or less in length. Not reniform. Ratio, length, width, thickness = 0.4 : 0.29 : 0.24 — Pea

Using this key, the field beans were classified as follows:

Kidney Group: White Kidney, Red Kidney.

Marrow Group: Brown (Swedish select), Old Fashion Yellow Eye, Improved Yellow Eye, Marrow.

Medium Group: Day's Leafless, York State Medium, and Blue Pod Medium.

Pea Group: California Small White, Rice, Marrow Pea, California Wonder, Boston Small Pea, American Wonder, York State Pea.

Probably the larger quantity of the beans grown belongs to the pea group; then follow in order of production the medium, kidney, and marrow groups. Co-operative experiments conducted by the Cornell Station indicate that in New York State the pea and medium beans outyield the marrow and kidney types.[1]

265. Distribution and Yield.—Field beans are grown principally in southern Michigan and western New York. The total production in the United States in 1899 was 5,064,844 bushels from 453,867 acres, an average of 11.2 bushels per acre. The legal weight per bushel in most of the states is 60 pounds. In 1899 the farm price ranged from one to two dollars per bushel in different states.

The total area devoted to field beans in Ontario, Canada, is about 50,000 acres annually. The average yield of six high yielding varieties at the Ontario Agricultural College for nine years was 21.8 bushels.[2]

[1] New York Cornell Sta. Bul. No. 210 (1903), p. 243.

[2] Ontario Agricultural College and Experimental Farm Rpt. 1905, p. 193.

Variations in measured weight per bushel ranged from 57 to 65.7 pounds; while 12 out of 13 varieties gave upwards of 62 pounds per measured bushel in the average of eight years' experiments.[1] The result of one season's test of four varieties on one-fortieth-acre plats on a loam soil of good quality in Ottawa indicated an average yield of 32.2 bushels per acre, with an average weight of 63 pounds per measured bushel after cleaning.[2]

The producers generally sell to dealers by sample on the basis of the percentage of perfect seeds. The dealers sort the seeds partly by machinery and partly by hand, before placing them on the general market.

266. Adaptation.—Field beans do best in cool, moist climates. East of the Rocky Mountains the climate south of the forty-first parallel is unsuited to their growth. While influenced more by climate than by soil, yet field beans succeed best on loam and especially on calcareous soils. Neither very heavy clays nor light sands are adapted to their growth. Nor are soils which are made light by a superabundance of organic matter desirable, since such soils produce a rank growth of vine, which is subject to disease, and whose seeds ripen unevenly. Land which will produce good maize and good wheat is suited to beans; but heavy clays, which are good for wheat but not for maize, and light soils that are good for maize but not for wheat, are not desirable for beans.

While beans will grow on relatively poor soil, yet for profitable production, they require one that is fairly fertile. It is believed that the larger beans, kidney and marrow, require a richer soil for profitable production than the smaller medium and pea beans. The rotation usually practised is beans, wheat, clover, each one year; or maize or potatoes, beans, wheat, and

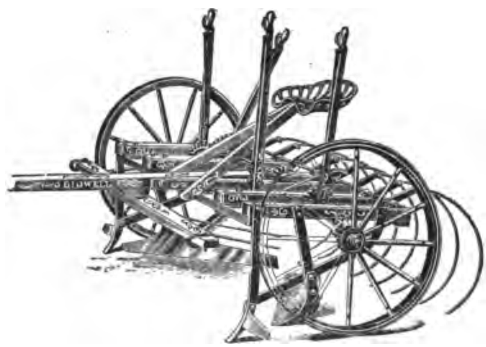
[1] Ontario Agricultural College Bul. No. 140 (1905), p. 26.
[2] Experimental Farms Rpts. 1905, p. 226.

clover. In these rotations, the pea and medium beans have the advantage, since they mature earlier than the larger sorts, and thus permit the thorough preparation of the soil for wheat. Fall or early spring plowing and thorough fitting of the soil is desirable for this crop. Since the crop is a late sown one, the tendency is to delay the plowing, much to the detriment of the crop.

267. Planting.—In general, kidney beans should be planted in the latter half of May; medium and pea beans from June 5 to 20, and marrows in between. There is danger of too early planting. Beans are a tender plant. They are killed by light frost, and the seeds are likely to rot in the ground, if it is wet and cold. When they start under unfavorable conditions, the strongest and best plants germinate first, producing an unequal growth, and causing an unequal ripening. Field beans are usually planted in drills. The pea and medium type are planted with the ordinary grain drill, stopping the tubes that are not needed; thus, with a drill having hoes seven inches apart, the rows may be 28 to 35 inches apart. Special bean planters are used for kidney beans. The number of seeds per pound varies with the types about as follows: kidney, 780; marrow, 1,000; medium, 1,400; pea, 2,200. The amount of seed used varies from two to three pecks with pea beans to five or six pecks with kidney beans. Great care should be exercised to secure seed free from anthracnose, and not infested with bean weevil. (270, 271)

268. Culture.—The cultivation is similar to that given to maize; but more care is required, since the young plants are tender and easily broken. In order to keep weeds from starting, especially in the row, the land should be harrowed one or more times before the beans come up. After the plants have dropped their beans (cotyledons) they should be cultivated, running as close to the row as possible, covering the weeds in the row; if the beans are covered with mellow earth at this time, they will usually come through again without injury. By harrowing before the plants are up, and by careful cultivation at the right time, hand hoeing may be largely, if not entirely, avoided.

As the plants become older, they should not be cultivated while the leaves are wet with dew or rain, for fear of spreading anthracnose. When dry, the anthracnose spores are held fast by a gummy substance, but which is at once dissolved by water, thus setting free the spores. Any disturbance of the plant when wet will therefore scatter the spores and spread the disease.[1] If



Bean harvester. It gathers two rows at a time and bunches the vines by means of attached rake

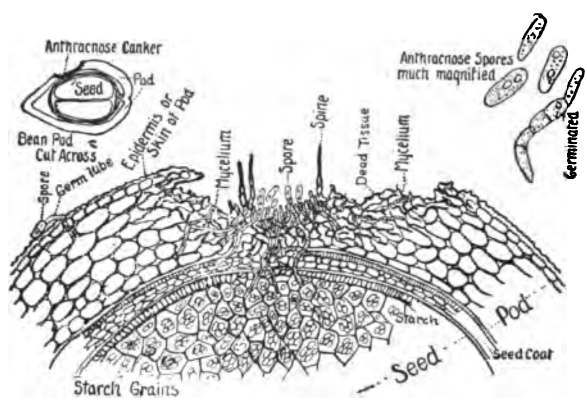
the field had been thoroughly "tended," it is best not to cultivate after beans come in blossoms; if necessary to cultivate later, wait until the blossoms have set.

269. Harvesting.—Beans may be pulled by hand, but the bean harvester which pulls or cuts two rows at a time is now generally used. As pulled, they are collected in small piles. Subsequently they are placed in larger piles, and when dry are stored in the barn. If wet weather ensues, the piles must be turned frequently, since if the pods remain in contact with the ground seeds are discolored and their sale injured.

[1] New York Cornell Sta. Bul. No. 239 (1906), p. 204.

270. Diseases.—Three diseases occur rather commonly on field beans. In order of their abundance and destruction they are: anthracnose or pod spot (*Colletotrichum lindemuthianum* (Sacc. and Magn.) Bri. and Cav.); bean blight (*Bacterium phaseoli* Erw. Sm.) and bean rust (*Uromyces appendicularis* (Pers.) Link.).

Anthracnose is a fungous disease known by its brown or black spots on stems, pods, or leaves. The disease also affects the seeds, which show reddish-brown or black spots and are often shrunken or shriveled. The seed harbors



The relation of the anthracnose fungus to the tissues of the bean. To the left above is diagram of a section across a bean pod through an anthracnose canker. The large drawing below is a much enlarged view of a portion of this same section. It is largely diagrammatic. It shows how the mycelial threads of the fungus may penetrate the seed coat and enter the starchy tissue of the seed, there to remain dormant until the following season. On the left of the large drawing is shown a spore germinating and penetrating the epidermis. This germ tube branches, spreads through the tissues of the pod and so gives rise to a new spot or canker. To the right above is shown a magnified view of some of the spores of the anthracnose fungus. One has germinated.

(After Whetzel)

the fungus, which develops on the cotyledons of the young seedling, from which it may spread to older and healthy plants. It is a destructive and much-dreaded disease. Three steps in combating this disease are recommended: the selection of disease-free seed, the removal of diseased seedlings, and spraying with Bordeaux mixture. Seeds themselves have not been successfully treated, because the fungus is embedded in the seed, and thus far no substance has been found which will destroy the fungus without injury to the germination of the seed. Since the disease is from without and local to the spot attacked, as shown in the illustration, spraying with a fungicide is the best means of preventing this disease. The Cornell Station recommends 5 pounds of copper sulphate, 4 pounds of stone lime to 50 gallons of water.[1] Too strong a solution may injure the plant. The first application should be made when the first pair of true leaves begins to unfold, about two weeks later, and again when pods are forming. Lands for beans should not receive manure made by feeding bean straw, especially if the straw is diseased.

Bean blight is a bacterial disease, producing on the leaves and pods large watery patches. On the leaves the spots become dry and brittle, and on the pods soft and rotten, but not shrunken and black, as in anthracnose. The pods are not destroyed unless attacked when they are young, but the bacteria may gain entrance to healthy appearing seeds, and thus propagate the disease when these seeds are planted. It is much less common and destructive than anthracnose. There is no demonstrated method of combating the disease. Seeds which have come from affected fields should not be planted, and the tops from such fields should be destroyed by fire, and the fields so affected should not be used for beans for some years, although the length of time a field may remain infested is not known. Spraying as for anthracnose, but oftener, is, however, recommended.

Bean seedling showing the anthracnose spots on stem and seed leaves. (After Halsted)

Bean rust is a fungous disease occurring principally on the under side of the leaves, and rarely upon the stems or the pods, producing small rusty-brown or black spots. It is rarely destructive. As the disease winters in the old leaves, burning the tops is recommended. It is said to be combated by spraying as for anthracnose. This disease also occurs on the cowpea.[2] The downy mildew (*Phytophthora phaseoli* Thax.), occurring on lima beans, has not been reported on field beans.

271. Insects.—While there are a number of insects, which may damage field beans, such as bean leafbeetle, bean ladybird, blister beetles, cutworms and other caterpillars, plant-bugs, leaf-hoppers and plant lice, the special and most destructive enemy of the bean is the common bean weevil (*Bruchus obtectus* Say).[3] This insect and the fungus, anthracnose, are the two great obstructions to the culture of beans. It is impossible to raise field beans extensively south of the forty-first parallel on account of the attacks of this insect, even were the climate suitable. It indeed may be a question whether it is the climate or this insect which restricts its culture. The bean weevil is a brownish beetle about one-eighth inch in length. The eggs are laid in the green pods in the fields. The larvae find their way into the maturing beans and continue to breed in the stored seed. A large number may develop in a seed. They are thus capable of exhausting the bean and ruining it for any

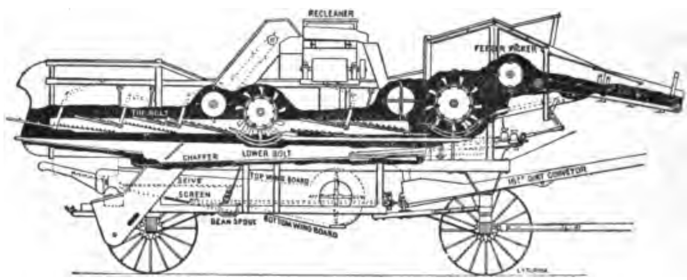
[1] New York Cornell Sta. Bul. No. 239 (1906), p. 207.

[2] Iowa Sta. Bul. No. 61 (1902), p. 139.

[3] "Insects injurious to beans and peas"; in U. S. Dept. Agr. Yearbook 1898, p. 233.

purpose. The entire life cycle varies according to season and locality, more particularly the temperature of the storeroom, from 21 to 80 days. Chittenden estimates six generations in a latitude such as the District of Columbia, with a less number farther north. Insects may be destroyed in the infested seeds without injury to the germinating power by fumigating with bisulphide of carbon at the rate of one ounce to every hundred pounds of beans; or by heating to a temperature of 145° F.; or by soaking seed for one minute in boiling water. Badly injured seed will float in water, and may be removed and destroyed. No other efficient means of preventing a field from being attacked has been found.

272. Threshing.— A special type of thresher is required for threshing beans and peas. When the bean pods are thoroughly



Sectional view of bean thresher. Note the two cylinders

dry, the seeds are readily separated from the pods, and are easily split. When damp, the seeds are separated from the pods with difficulty, and the seeds are less easily split. If the pods in a load of beans were all of equal dryness, they could be threshed fairly well by speeding the cylinder of the thresher to suit the state of dryness; but if, as usually happens, the pods vary as to dryness, no speed of the cylinder will be best for all. If the speed is too high, some will be split; if too low, not all the beans will be obtained. This difficulty is met in bean threshers and pea hullers by having two cylinders run at different rates of speed. The beans are run through a cylinder at low speed, which threshes out the dry pods, the seeds of which are thoroughly screened out before the partly threshed material comes to the second cylinder run at a higher rate of speed. Skill in adjusting the speed of the machine to the condition of the beans to be threshed is essential, in order to get all the beans without splitting any.

Beans, being an annual, thinly planted, inter-tilled crop, do not have the stubble to keep them off the soil; consequently a good deal of dirt and, sometimes, stones are picked up with the vines which are to be threshed. Special devices for removing the dirt and special precautions against the breakage due to stones are therefore required. Some bean threshers have recleaners attached which break up the lumps of dirt and separate the material after it has thus been made fine. Less beans are split when they are threshed with a flail, and although it is much slower, some prefer this method.

273. History and Use.—Commercial bean growing in the United States may be said to have begun in Orleans County, New York, in 1839.[1] The production of beans was given an impetus in the early sixties, because of their use in the army and navy, and more recently to a less extent by the Spanish-American War. The recent practise of canning beans has also extended their use. Beans are not much used for domestic animals, although they are employed for this purpose somewhat more largely in Canada than in the United States. Locally, however, cull beans may be obtained at a price that makes them an economical and desirable food. They may be fed raw to sheep, but must be cooked in order to be eaten by cattle or swine. Bean straw, when fed in connection with other foods, makes a fairly desirable food for sheep and dairy cattle. It contains a higher percentage of protein than timothy hay. It is laxative when fed too freely.

[1] History of the bean industry; in Transactions N. Y. State Agr. Soc. for 1897, p. 323.

II. FIELD PEAS

274. Relationships.—The field pea (*Pisum sativum*, var. *arvense* Poir (*P. arvense* L.), also known as Canada field peas, differs slightly from the garden pea (*P. sativum* L.). Field peas usually have violet flowers and smaller gray or buff seeds, which are rather angular, but not wrinkled, while garden peas have white flowers, and whiter and more globular seeds, which may be either smooth or wrinkled. Of the two types, field peas are rather the more hardy, and perhaps the more upright in habit.

275. Description.—The field pea has hollow, sparingly branched stems two to six, usually three to five, feet long, with leaves six or more inches long, bearing usually two or three pairs of leaflets one or two inches long, with large leafy stipules at the base, and one or more pairs of tendrils at the upper end, the tip of the midrib terminating in a tendril. The young plants are erect, but as they grow older they become decumbent unless they are supported. While the plant has a vine-like habit of growth, it is not twining, but climbs by means of leaf tendrils. Two or more rather large flowers are borne in the axils of the leaves on flower stalks, which are shorter than the leaves. The pistil grows into a rather flat, many-seeded legume two to four inches long. All the vegetative portions of the plant are smooth and glaucous, and the tissues succulent; in the green state these portions are especially well liked by domestic animals.

At the North Dakota Station it was found that the plants 86 days old having vines 5.5 feet long, had roots reaching three feet in depth, though rather sparingly supplied with branches and fibers. Most of the fibrous roots were within eight to ten inches of the surface[1]. The Michigan Station reports that Gol-

[1] North Dakota Sta. Bul. No. 43 (1900), p. 535.

den Vine field pea produced stem vines averaging 9.5 feet in length.[1] The Utah Station found with the Golden Vine variety the greatest yield of both green and dry matter was when the plant was in flower, the yield of water-free substance being: whole plant, 4,997, leaves 2,347, stalks 1,391, and flowers 259 pounds. Two weeks later, when the pods were mature, the yield of water-free substance was: whole plant 3,496, leaves 1,699, stalks 698, and pods 1,108 pounds. The percentage of leaves decreased from youth to maturity; the percentage of stalk increased until the pods began to form, when it then decreased.[2]

276. VARIETIES.—Among 33 varieties at the Minnesota Station, the best yield of grain was obtained from White Canada Field, 20.3 bushels. Other varieties, Alpha, Blue Prussian, Crown, and Green Canada Field, held good rank, none of these falling below 17 bushels per acre. The lowest yield of any variety was 11.1 bushels. Most of the varieties matured within 90 days, the extremes being 79 and 100 days. In fourteen tests of two varieties, the Canada Station found Early Britain to lead with 32.6 bushels of grain and 1.7 tons of straw per acre.[3] After an experience with about 100 varieties lasting over a period of fifteen years, the Ontario Station[4] makes the following recommendations, based principally on grain production: for very rich soil, White Wonder; for soil of medium quality, Early Britain and New Canadian Beauty; for poorer soils, Prussian Blue and Tall White Marrowfat. Among the most productive sorts grown for five years at the Canadian Experimental Farms are Golden Vine, Victoria, Mackay, White Wonder, Prince, Canada Beauty and Prussian Blue.[5]

Of three varieties tested by the Massachusetts Hatch Station, there was little difference in yield of green pea vine between Prussian Blue and Canada Beauty, while English Gray was rather low. At the Wyoming Station, Golden Vine and Mexican matured in August, while White Canadian and Green Canadian matured in September. The varieties most frequently mentioned by other stations are Golden Vine, Prussian Blue and Canada Beauty.

277. **Distribution.**—While peas have been rather extensively raised for their seeds in Canada as well as in Europe, in the

[1] Michigan Sta. Spec. Bul. No. 28 (1904).
[2] Utah Sta. Bul. No. 69 (1900), p. 313.
[3] Canada Experimental Farms Rpts. 1893, p. 328.
[4] Ontario Agr. Col. Bul. No. 140 (1903), p. 25.
[5] Canada Experimental Farms Rpts. 1905, p. 223.

United States they have been less largely grown. For this purpose they are less extensively grown in the United States than are field beans or cowpeas. Michigan and Wisconsin raise field peas most extensively, the average yield in 1899 being about 16 bushels per acre. In Canada 35 and 40 bushels per acre are reported in individual instances. The legal weight per bushel in Canada and in the United States is 60 pounds.

For soiling, dry forage, or mixed grain, field peas mixed with oats are grown in relatively small quantities. (Ç. A., 405) They deserve, in the northern portions of the United States and throughout Canada, a wider use for this purpose. Owing to the ravages of the pea weevil, the acreage of field peas in Canada in recent years has become greatly reduced. (280)

278. Adaptation.—Any soil that will raise oats will raise field peas, although like other legumes, field peas will do best on calcareous soils. Sandy soils are better than clay soils. Those cool, moist climates in which oats find their best development are also best for field peas. Artificial inoculation has not ordinarily been found necessary, but the Alabama Station found in pots an increase of 200 per cent. in yield of vines through inoculation as compared with plants in which no inoculation occurred.[1]

279. Seeding.—The pea has a high germinating power, and will germinate at quite a low temperature. In order to get the largest amount of growth possible in the coolest and moistest portions of the year, the seeds should be sown as early in the spring as the soil will permit. One reason sandy soils are better than clay soils is that the former permit earlier sowing. For the same reason fall plowing is desirable.

Peas do best when sown quite deeply. If sown broadcast, covering with a disk harrow or by light plowing is recommended. Usually, perhaps, the ordinary grain drill is preferable, pro-

[1] Alabama Sta. Bul. No. 87 (1897), p. 472.

vided care is taken to use one that does not split the seeds while planting, which, sometimes occurring, causes quite a reduction in the stand. The rate of seeding varies from 1.5 to 3.5 bushels per acre.[1] The Ontario Station, after testing for six years, found that by selecting seed for sowing, the results showed an average of 28.1 bushels per acre from large seed, and 23 bushels from small seed.[2]

280. Diseases and Insects.—Diseases rarely do much damage to field peas. Field peas are sometimes severely damaged by blight (*Ascochyta pisi* Lib.) and occasionally attacked by the powdery mildew (*Erysiphe polygoni* D. C.). The latter may be checked by spraying with Bordeaux mixture. In the absence of a successful remedy for the former, planting sound seed in soil free of the fungus may serve as a prevention.[3] While other insect attacks occasionally occur, the one enemy to pea culture, and especially to the production of sound seed, is the pea weevil (*Bruchus pisorum* L.). This is larger than the bean weevil, being about one-fifth inch long. This insect lays its eggs upon the young pea pods, which upon hatching burrow into the pea, never more than one weevil to each pea, where, as the seeds mature, it lives and develops into an adult beetle. In the green peas, the minute dot by which the larva entered is not ordinarily noticed and consequently the larvae are often consumed in large numbers. In dry seeds, the cell inhabited by the insect may be seen under the skin, while later the adults bore holes in the skin through which they escape. Unlike the bean weevil, they do not breed in dry seed, and there is only one generation; hence if prevented from laying their eggs upon the pea pods, they must perish.

Advantage is taken of this fact in two ways: (1) If infested seed is held in a tight receptacle until the second year, all insects perish, and the seed may be planted without being the source of the insects. Infested seed, however, is very low in germinating power, and seed which germinate are often mutilated and of little value. (2) If seed are planted late after the breeding of the insects, peas may escape attack and sound seed may be secured. Insects may be destroyed, also, by the same means mentioned for the bean weevil. (271) The pea weevil is less active in the northern tier of states and in Canada, which accounts, in part, at least, for the culture of field peas being restricted largely to that region.

In Canada it was found that by suspending culture of the crop, at the end of three years the weevil was almost completely eradicated. Treating with carbon bisulphide immediately after threshing has also resulted in their complete destruction.[4] Spraying the vines with Paris green just after the

[1] For method of seeding with oats, see (C. A. 405).

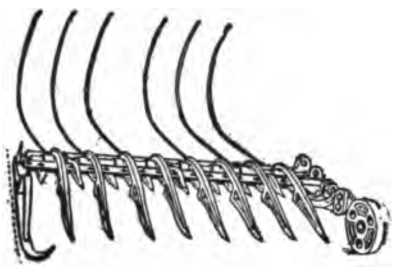
[2] Ontario Agr. Col. and Expt. Farm Rpt. 1905, p. 191.

[3] Ohio Sta. Bul. No. 173 (1906), pp. 233-246.

[4] Ontario Agr. Col. and Expt. Farm Rpt. 1905, p. 191.

pods were formed was not found effective, but early varieties of peas were found much less liable to be injured than later sorts.[1]

281. **Harvesting.**—Because of their prostrate habit of growth, and because of the readiness with which the drying and dried pods open and scatter their seeds, the harvesting is rather difficult. They may be cut with the ordinary mowing-machine, and raked into piles with a sulky rake, using only one end of the rake, in order that the horse may not walk upon the vines. A pea harvester attachment is sometimes used. It is customary to harvest when two-thirds of the pods are yellow. When dried they may be stacked under cover, or threshed immediately with a pea huller or with the ordinary thresher, although the latter chops the straw or haulms rather fine. (*272*)



Pea harvester with buncher attached

282. **Uses.**—Native of Italy, the field pea has been cultivated for many centuries, chiefly for its grain. The straw is especially prized by the Canadian shepherds. Peas may be used whole or ground into meal, when they make excellent food for cattle, sheep, and swine. Pea flour is an ingredient of food preparations for infants, invalids, and others, and split peas, freed from the hulls, are used in soups and other culinary articles. Varieties of the field types are also used for canning.

III. PEANUTS[2]

283. **Description.**—The peanut plant (*Arachis hypogaea* L.) "is a trailing annual, growing from one to two feet high,

[1] Canada Experimental Farms Rpts. 1905, p. 311.

[2] This section on peanuts is largely drawn from "The Peanut Plant," by B. W. Jones: Orange Judd Company, and "Peanut: Culture and Uses," by R. B. Handy: U. S. Department of Agriculture, Farmers' Bul. No. 25.

with thick, angular, pale-green, hairy stems and spreading branches, and has the peculiar habit of maturing its fruit underground." After the blossom falls, the ovulary is pushed into the ground through the elongation of the peduncle or "spike," where it develops into the well-known pod, one to two inches long, and containing one to four, usually two, seeds. The cinnamon-yellow roots are abundantly supplied with tubercles.

284. Composition.—The peanut kernel is characterized by its high percentage of fat, and when the oil has been extracted, the resulting meal is characterized by its high percentage of protein, as shown in the following table:

Food Constituents in Different Parts of Peanut Kernel

Parts	Water	In Water-free Substance				
		Ash	Protein	Fiber	Nitrogen-free extract	Fat
Peanut kernels	7.9	2.8	29.5	4.3	14.2	49.2
Peanut meal	10.7	5.5	52.5	5.9	27.3	8.8
Peanut vines, cut before blooming	31.2	10.7	12.6	22.3	48.3	6.1
Peanut vines, cut when fruit was ripe	31.9	12.1	10.8	32.3	39.8	5.0

285. Varieties.—Peanuts may be classified according to their habit of growth into running and bunching varieties; according to the redness of their skin (testa) into white and red varieties; and according to the size of the pods. In general, two well-defined types are recognized: those with large pods, usually sold for roasting, as "Virginia hand-picked" peanuts, and those with small pods, known as Spanish peanuts. The Spanish variety has a relatively small, upright vine, which permits closer planting than in the running, large podded varieties. The Spanish peanut is not ordinarily sold in the shell, but is used shelled by confectioners. It is also recommended as a forage plant, having a wider climatic and soil adaptation than the larger varieties.

The Arkansas Station states that as a hog food nothing has been found which will more cheaply produce gain than the

The mature peanut plant showing the ripened fruit and the many-branched tap root with tubercles
(After Handy)

Spanish peanut. One-fourth acre of peanuts produced 313 pounds of pork, while the same area of maize produced 109 pounds. At the Alabama Station, 503 pounds gain of pork per acre was made in six weeks upon peanut pastures alone.[1]

286. Distribution and Yield.—There were grown in 1899 about twelve million bushels of peanuts on about one-half million acres, or about 23 bushels per acre. Fifty bushels per acre of the large podded sorts are considered a satisfactory yield. The Arkansas Station produced 144 bushels of Spanish peanuts on a highly fertile soil, while on a less fertile soil the Virginia white variety yielded 114 bushels per acre, and the Spanish yielded 109 bushels. After the nuts have been harvested, a yield of one to three tons of hay may be obtained. A bushel of the large podded varieties weighs 22 pounds and yields

[1] Arkansas Sta. Bul. No. 84 (1904), p. 120.

15 to 17 pounds of kernels, while a bushel of Spanish peanuts weighs 30 pounds and yields about 20 pounds of kernels.

Peanuts are produced principally in the South Atlantic states, and in Alabama and Tennessee. About one-half the total production comes from southern Virginia and North Carolina. The production is increasing rapidly, it having trebled in the past decade.

287. Adaptation.—The peanut requires at least five months without frost, a hot, moist summer, and, for good market quality, but little rainfall during harvest. A loam soil containing an abundance of lime and not too large quantity of humus is best. Where lime is deficient there will be a large proportion of empty pods or "pops," and where humus is excessive the plant has a tendency to "run to vine." A sandy soil free from iron produces the best market quality, because pods are less likely to become stained, but does not necessarily produce better yields than soils containing more clay. The Spanish variety may be grown for forage on any soil on which maize can be grown south of the thirty-seventh parallel of latitude.

288. Soil Amendments.—If the soil is deficient in lime, one ton of quick lime or three tons of marl may be applied per acre. Applications of stable manure when needed are best applied to the previous crop, which should be a cultivated one, such as maize, cotton, or tobacco. Phosphoric and potassic rather than nitrogenous commercial fertilizers are indicated. Nevertheless, fertilizer formulas sometimes include cotton seed meal as well as acid phosphate and kainit.

289. Planting.—The soil is prepared as for maize or potatoes, although perhaps with rather more care. The furrow may be opened with a small plow two to three and one-half, usually three, feet apart. The seeds are generally planted by hand four inches to two feet apart in the row. The Arkansas Station concludes that for the Spanish variety the best yields will be obtained from rows 30 inches apart with the peanut four to twelve inches apart in the row. In some cases peanuts are planted in hills so they may be cultivated both ways. The seeds are covered one and a half to two inches deep with a hoe or with the foot. Only one plant in a place is desired, but in some cases two seeds are planted. Planting should occur as soon as all danger from late frosts is over.

"Spanish peanuts intended for grazing by hogs may be planted at any time after danger of frost is over on to the first or middle of July in north Arkansas, and as late as the middle of August in the southern part of the state. The time and methods of planting this variety of peanuts for hog feed is quite adjustable, and the crop may be associated with almost any system of cropping practised in the South. The most profitable practises with this variety consist in growing the peanuts with some other crop, as corn, or after some crop has been harvested." [1]

290. Seed.—For planting, two bushels of seed in the pod are required per acre. Considerable care is required in harvesting, storing, and selecting suitable seed for planting, otherwise the germination is likely to be low. In the case of the larger varieties, the pods are removed before planting by hand, care being taken not to break the skin. The Spanish variety may be planted without shelling or after merely breaking the pods in two, although this is not a desirable practise.

"A test made at Fayetteville in 1900 gave 98 per cent. germination from shelled, 91 per cent. from pods broken in two, and 78 per cent. from whole pods. The plots planted with the whole pods were very slow in sprouting, and some were about five weeks in appearing above the ground. The broken pods did better, but were not so prompt to germinate as were the shelled nuts. An attempt to hull several varieties of peanuts in a cowpea huller was very unsuccessful with the larger Virginia and Tennessee varieties, but gave satisfactory results with the Spanish. About 20 per cent. were split by the pea huller, but their loss were more than compensated for by the time gained. Could some means have been devised for cheaply separating the split from the whole peanut the work would have been quite satisfactory." [2]

291. Cultivation.—The cultivation of peanuts is similar to that described for field beans. It is desirable to have the

[1] Arkansas Sta. Bul. No. 84 (1904), p. 128.

[2] Arkansas Sta. Bul. No. 84 (1904), pp. 122, 123.

land free from weeds and friable at the time the flower stems strike into the ground, but it is advisable to have cultivation cease before this occurs. Covering the blossoms with soil is injurious. Experiments have shown a decrease in the yield of more than a fourth, compared with not covering the vines.

292. Harvesting, which usually occurs in September and October, should be done before frost, since both the vines as fodder and the kernels are injured if frosted. The crop is lifted by a special plow having long cutting flanges welded to the point and no moldboard. "The plow is run deep enough to sever the tap root, without disturbing the pods. The vines are then lifted from the ground with pitchforks, and placed in rows; they are afterwards stacked around short poles. Two weeks later the pods should be dry enough to be picked off. After picking the nuts are placed in bags, holding four bushels, and either stored away in dry, well-ventilated sheds, or at once sold to the 'factories,' where they are cleaned, sorted, sacked, and branded. They are then ready for the trade."[1]

293. Uses.—Peanuts are sorted into four grades, the first three grades being sold to venders of roasted peanuts; while the fourth grade is sold to confectioners to be used in peanut candy and for similar purposes. The kernel is recognized to have a high food value and its use for human consumption will doubtless continue to increase. Peanut butter is a paste prepared from the seed after removing the shell and skin. An oil is extracted from the kernel similar in character and use to olive and cotton seed oil, and the remaining peanut meal is one of the most nutritious and highly prized concentrated cattle foods. All classes of domestic animals are fond of peanuts and thrive upon them; while the whole plant either as pasture or hay is a nutritious forage for horses and cattle.

[1] U. S. Dept. Agr., Farmers' Bul. No. 25, p. 23.

Practicum

294. Field Beans.—1. Seed Study: Make drawings showing the general shape, hilum = point of attachment, micropyle = point at the free end of the radicle or caulicle, raphe = ridge from opposite end of the hilum to end of the seed.

Divide the bean into its two cotyledons and make drawings showing the testa = seed coat, the tegumen = body of cotyledons, the plantlet, pointing out the radicle = free and pointed end of the plantlet, node = point of attachment of the cotyledon, first pair of leaves, internode.

2. Seedling: Make drawings and note upon them if there are any roots, changes in the plumule, change in seed coat, consistency of tegumen, length of radicle.

3. Plant, if bush bean: runners present, absent; growth rank, slight; growth upright, spreading; many-stemmed, few-stemmed; short-stemmed, long-stemmed; pods on runners, pods in center of plant; pods few, many.

4. Pods: length.........in.; average number of beans.........; symmetrical, asymmetrical; straight, curved, twisted; depression between beans slight, marked; pods well filled, not well filled; beans crowded, not crowded; section large, small; flat, oval; back creased, not creased; surface rough, smooth; healthy, diseased.

5. Seed Inspection: Count 100 beans and weigh them. Average weight of individual..........; average length..........; average width..........; average thickness..........; ratio of width to length..........; ratio of length to thickness..........; ratio of width to thickness..........

6. Shape of bean: kidney-shaped, symmetrical; cross-section oval, flat, round.

7. Color: mottled, splashed, striped; if uniform, white, black, brown, red; eye yellow, black, not colored.

295. Collateral Reading.—B. W. Jones: The Peanut Plant. New York: Orange Judd Co., 1902.

W. N. Roper: Peanut and its Culture. Petersburg, Va.: American Nut Journal, 1905.

H. C. Irish: Garden Beans Cultivated as Esculents. In Missouri Bot. Garden Report 1901, pp. 81-8.

T. E. Browne: Peanut Culture. In The Bulletin, North Carolina Dept. Agr. (October, 1906), pp. 23-7

R. B. Handy: Peanuts: Culture and Uses. U. S. Dept. Agr., Farmers' Bul. No. 25, 1895.

Thomas Shaw: Canadian Field Peas. U. S. Dept. Agr., Farmers' Bul. No. 224, 1905.

Mary Hinman Abel: Beans, Peas, and other Legumes as Food. U. S. Dept. Agr., Farmers' Bul. No. 121, 1900.

C. A. Zavitz and Wm. Lochhead: Peas and the Pea Weevil. Ontario Agr. Col. Bul. No. 126, 1903.

J. M. Van Hook: Blight and Mildew of the Field and Garden Peas. Ohio Station Bul. No. 173, 1906.

XIII

LEGUMES FOR SEED

COWPEAS

296. Relationships.—Cowpeas (*Vigna sinensis* (L.) Endl.; *Dolichos sinensis* L.; *Vigna catjang* Wallp.), or, as more appropriately called in Europe, China beans are not properly speaking a pea, although they resemble the pea in form of blossom and fruit. In general appearance, in its habit of growth, and in the character and composition of its seeds, it much more resembles the common field and garden beans (*Phaseolus*) than do soy beans.

297. Roots.—The well developed tap root bears from its upper part large branches which spread out almost horizontally from one to two feet when they turn downward, some reaching a considerable depth. Roots 42 inches have been noted, but the bulk of the roots is within 15 inches of the surface. Rootlets and root hairs are numerous. Cowpea roots are nearly white, and the abundant root-tubercles have a tendency to follow along certain roots in disconnected chains. The Kansas Station believes that on account of its much stronger and more extensive root system it will not bear as close planting as soy bean. For this reason, also, and because of the readiness and universality with which root-tubercles are formed, it is better adapted to improving the soil.[1]

298. Common Characters.—The stems are striped with longitudinal grooves and bear three large leaflets, two to six inches long and wide, the terminal one long-stalked and symmetrical,

[1] Kansas Sta. Bul. No. 127 (1905), p. 223.

the lateral ones short-stalked and oblique. The yellowish flowers are few on long stalks. The pods are cylindrical, fleshy, nearly straight, and many-seeded.

299. Variable Characters.—This plant is noteworthy on account of its variable habit of growth under different conditions of climate, soil, and culture. There are in this country about 70 named varieties, some of which are probably synonyms. The cowpea has naturally, perhaps, a trailing habit, but varies from a bush with an erect single stem one foot high and short lateral branches to a vine with prostrate stems and trailing branches 15 to 20 feet in length. The cowpea does not twine as in the case of pole field beans, nor does it have tendrils as in the case of field and garden beans.

Leaf and pods of the cowpea
(After Smith)

The seed may be smooth or wrinkled, though the former type is much the more common. The seeds vary from about 75,000 to about 270,000 per bushel. With Clay, Whippoorwill, and Wonderful (Unknown) varieties, there are about 150,000 seeds per bushel. The amount commonly sold for a bushel is 60 pounds; the actual weight per measured bushel may vary from 51 to 61 pounds. The Arkansas Station obtained with Warren's Extra Early 44 per cent. of shelled peas from the cured plant, while with Red Ripper 17 per cent. was obtained.[1] In the case

[1] Arkansas Sta. Bul. No. 70 (1901), p. 95.

of late maturing varieties, no pods may be formed. The per cent. of shelled peas to pods or unshelled peas may vary from about 50 to 85. The pods may be brown, purple or blackish, though light yellow is the prevailing color. They vary somewhat in diameter, and in length from 5 to 10 or more inches. The shape of pods and shape of seeds are to some extent related, and give rise to two types with many gradations between:

(1) A rounded form so closely packed in the pod that the sides of the pea are flattened or indented, giving the pod a tightly stuffed, corrugated, plethoric appearance. This class of pea is known as *Crowder*.

(2) A flattened form, kidney-shaped, and placed farther apart in the pod, which is smoother and leaner in appearance. The pods of *Crowders* are generally quite stubby and short; those of the *Kidney* type are long.[1]

The color of the seed is extremely variable, consisting of solid or mottled shades of white, yellow, green, pink, purple, red, brown, and black. A ring around the scar is common, giving rise to names of varieties, such as "black-eyed" or "purple-eyed." There is also a great variation in the time required to ripen seed, which may vary from two to seven months. Early planting, excess of moisture and of nitrogen will prolong the period of growth in the same variety. There is a somewhat constant relation between the period of growth and the habit of growth. Early maturing varieties are dwarf or bushy and usually produce seed, while those with trailing habit are later in maturing and produce greater abundance of vines, but usually produce no mature seed north of the South Central states.

300. Variations Due to Environment.—It is commonly held that the habit of growth of different varieties of cowpea varies greatly with the climatic conditions. It is said that erect bush varieties become trailers when taken southward, when sown unusually early or upon very wet soil; while trailers assume the bush habit when taken northward or planted quite thickly.

[1] Georgia Sta. Bul. No. 26 (1894), p. 171.

The Delaware Station[1] obtained seed from several sources ranging in latitude from Texas to Virginia, and compared the growth with plants from seed grown at their own station for several years. They found no evidence, where the identity of a variety was beyond question, as the Whippoorwill, that seed grown in the far south required any longer season for maturing a crop than that grown some hundreds of miles farther north. They note, however, that there is some evidence that seed of any variety grown in their own state will produce better yields than that grown farther south. The Cornell Station[2] grew seed obtained from North Carolina, Arkansas, and Louisiana. The black and clay varieties from North Carolina matured seed well, but plants of the same varieties from Louisiana stock were too late. While the Michigan Station[3] matured Whippoorwill seed, and while certain varieties fruited at the Wisconsin Station,[4] the latter station, after experimenting four years with this crop, reports that the cowpeas ripen so unevenly, and the plants are of such a spreading character that their culture cannot be found profitable except, possibly, for soil renovation by plowing them under in the fall.

301. Classification.—The Louisiana Station[5] concludes from a thorough study of 63 varieties that there is but one species of all of the varieties of the true "cowpea," and that the number of varieties can be greatly reduced, probably to five, possibly to three. The solid colors, black, white, and red, are regarded as pure varieties and the others as fluctuating hybrids of these three. As in kidney beans, the characters of the seeds form the best basis of classification, although the character of the pods, the habit of growth and time of maturity may enter into

1 Delaware Sta. Bul. No. 46 (1900), pp. 21-3.

2 New York Cornell Sta. Bul. No. 61 (1893), p. 335.

3 See New York Cornell Sta. Bul. No. 61 (1893), p. 335.

4 Wisconsin Sta. Rpt. (1903), p. 276.

5 Louisiana Sta. Bul., 2d ser. No. 40 (1896), pp. 1441-2.

such classification. The Georgia Station has proposed the following as a basis for a systematic and uniform nomenclature:

1. Form of pea, main divisions: (a) Crowders, (b) Kidneys.
2. Habit of growth, divisions: (a) trailing, (b) recumbent, (c) semi-recumbent, (d) erect.
3. Time of maturity, divisions: (a) very early, (b) early, (c) medium, (d) late, (e) very late.
4. Color of pod, divisions: (a) dark, (b) light.
5. Color of peas: divisions too numerous to specify.
6. Size of pods, divisions: (a) very large, (b) large, (c) medium, (d) small, (e) very small.
7. Size of peas, divisions: (a) very large, (b) large, (c) medium, (d) small, (e) very small.[1]

302. Varieties.—The Georgia Station recommends varieties as follows: for hay, since they are erect, Unknown, Clay, Whippoorwill; for grazing, since they will remain on the ground all winter, Black, Everlasting, Red, and Red Ripper; as the heaviest producer of peas, Unknown, Calico, Clay, and White-Brown hull; as best table peas, Sugar Crowder, White Crowder, Mush, Large Lady, Small Lady, Rice; as the best all-purpose pea, Unknown (Wonderful) and Clay.[2] The Alabama Station reports the largest production of seed from New Era, Black, and Red Ripper; of hay, from Wonderful and Clay.[3] The Arkansas Station grew 123 samples embracing about thirty varieties under forty-five names. The heaviest yield of hay was obtained from Clay and the lightest from New Era and Black Eye. Wonderful (Unknown), Red Ripper and Clay grew very few peas. The varieties giving the highest yield of peas were Calico, Coffee, Extra Early Black Eye, Iron, New Era, Red Yellow Hull, Speckled Java, Warren's Extra Early, Warren's New Hybrid, Whippoorwill and White Brown Eye. New Era, Old Man's, Warren's Extra Early, Extra Early Black Eye, and Warren's New Hybrid yielded a greater proportion of peas to vines than other varieties tested, and are recommended for early planting.[4]

At the Illinois Station the best yield of seed was obtained with Warren's Extra Early, Warren's New Hybrid, Old Man's and New Era. Whippoorwill produced less than one-half as much seed as the varieties named, while Red Ripper, Wonderful, Lady, Clay, and Taylor either produced but few pods or failed to mature.[5] At the Tennessee Station the best yield of pea vine hay was with Taylor and Wonderful, while Clay, Black Eye and Whippoorwill each yielded above two tons per acre.[6]

[1] Georgia Sta. Bul. No. 26 (1894), p. 171.
[2] Georgia Sta. Bul. No. 26 (1894), p. 185.
[3] Alabama Sta. Bul. No. 118 (1902), p. 3.
[4] Arkansas Sta. Bul. No. 77 (1903), p. 32.
[5] Illinois Sta. Circ. No. 69 (1903), p. 5.
[6] Tennessee Sta. Bul. 14 (1901), No. 1, p. 15.

The Delaware Station[1] recommends New Era and Whippoorwill as the best varieties for that state, while next in favor are Black, Clay, Unknown (Wonderful) and Black Eye. Among 34 varieties the Kansas Station,[2] considering the quality of fodder with yield of fodder and of peas, found the following to be the more promising: New Era, Black Eye, Black, Warren's Extra Early, Old Man's, Whippoorwill, and Lady. The Kentucky Station[3] recommends Whippoorwill and Black Eye for forage, and Extra Early Black Eye and Large Black Eye for table use. With 28 varieties the Texas Station[4] secured an average yield of 15 bushels per acre, with Pearson Beau (35), Black (20), Mush, or Rice and Coffee (19) leading in yield of peas. Pearson Beau was one of the latest to mature (September 20), while Mush or Rice was the second to mature (July 25).

The Virginia Station[5] found the Southern, Wonderful, Iron, and Clay to be the most productive varieties for forage. The Louisiana Station recommends the Conch variety for forage. The Whippoorwill variety gave the largest yield of seed at the Mississippi Station.[6] The New Jersey Station[7] found Red Ripper the best variety, while Southdown, Small Black and Taylor were good. At the North Carolina Station the highest yields of peas among six varieties were obtained in the following order: Unknown, Red Ripper, and Clay. Oklahoma Station recommends Whippoorwill for general use. Rhode Island Station found Black, Blue, and Unknown to produce the heaviest yields of dry matter, each yielding above two tons per acre.

303. Cross-fertilization.—From 24 varieties the Louisiana Station[8] selected 78 growing plants. Each plant was surrounded with a wooden frame. Upon one-half of the frames mosquito netting was stretched, upon the other half thin muslin. When the pods had become three or more inches long no difference was noted in the covered plants. Matured seed was found in over 95 per cent., indicating that each flower is capable of self-fertilization. Neither honey nor bumble bees were observed to visit exposed plants. Attempted artificial fertilization gave negative results. While the structure of the cowpea flower is, like

[1] Delaware Sta. Bul. No. 46 (1900), p. 16.

[2] Kansas Sta. Bul. No. 123 (1904), p. 199.

[3] Kentucky Sta. Bul. No. 98 (1902).

[4] Texas Sta. Bul. No. 34 (1895).

[5] Virginia Sta. Bul. No. 149 (1903).

[6] Mississippi Sta. Bul. No. 84 (1904), p. 12.

[7] New Jersey Sta. Rpt. 1903, pp. 350-362.

[8] Louisiana Sta. Bul., 2d ser. No. 40 (1896), pp. 1447, 1448.

other legumes, such as to make cross-fertilization possible, it is probable that self-fertilization most commonly occurs.

304. Composition.—The following table compiled from different sources gives the water-free composition of different parts of the cowpeas as ordinarily used:

Table Showing Composition of Cowpeas

Analysis	Dry-shelled peas [1]	Vines with pods [2]	Vines without pods [1]	Stems [1]	Leaves [1]	Silage (Vines and pods) [3]
Ash . . .	3.4	9.9	6.9	6.4	11.6	10.0
Protein (N x 6.25)	26.3	18.4	10.4	6.9	18.4	14.3
Crude fiber . .	5.4	22.8	34.5	43.1	16.0	27.0
Nitrogen-free extract	63.4	42.8	46.1	42.6	46.1	45.8
Fat . . .	1.5	6.1	2.5	1.0	7.9	2.9
Phosphoric acid .	0.9		0 3	0.2	0.4	
Potash . . .	1.5		1.9	1.8	1.2	

305. Digestibility.—With cattle, cowpea silage is slightly less digestible than maize silage, contains about one-third less digestible fat and over twice as much digestible protein. Compared with the digestibility of clover when fed to sheep, it is somewhat more digestible with about the same relative proportion of digestible constituents. When fed to cattle, cowpea silage is nearly as digestible as when bran is fed to sheep, but in each one hundred pounds of dry matter eaten cowpea silage contains less than two-thirds as much digestible protein.[4] The Delaware Station reports an experiment, which showed that with milch cows, when cowpea vine silage was displaced by its chemical equivalent in the form of bran, the yield of milk

[1] Arkansas Sta. Bul. No. 24 (1893), p. 126.
[2] Oklahoma Sta. Bul. No. 6 (1893), p. 36.
[3] Illinois Sta. Bul. No. 43 (1896), p. 204.
[4] Illinois Sta. Bul. No. 43 (1896), p. 205.

and of butter fat was reduced, while no loss occurred when cowpea vine silage replaced its chemical equivalent in bran.[1]

306. Distribution.—While native of southern Asia and central Africa, cowpeas have come to be cultivated in nearly all the warmer regions. The United States may be divided in a very general way into three more or less overlapping regions with regard to the cultivation of legumes. In the North Atlantic and the North Central states, the clovers, red, mammoth, and alsike, constitute the principal forage crops with the kidney beans and the common field and garden peas the principal legumes for seed. In the states west of the Missouri River, alfalfa is the almost universal legume for forage, while the lima beans are grown somewhat on the Pacific coast for their seed. In the South Atlantic and the South Central states, the cowpea is as a forage crop what red clover and alfalfa are in the other sections; while its seeds largely take the place of the field and garden peas, the kidney and lima beans grown elsewhere.

In some sections, especially in the South Atlantic states, crimson clover becomes an economic factor, while the peanut occupies an important and increasing place in the Southern states north of the cotton belt. Economy of production has in some cases given crimson clover preference to cowpeas. It is estimated that in the cotton belt the acreage of cowpeas is greater than all other legumes combined.

307. Adaptation.—One reason, apparently, for the place which cowpeas are coming to occupy throughout the southern states is their ability to grow reasonably well upon a great variety of soils, assuming a sufficient degree of temperature and not too great moisture. They require a warm, fairly dry soil. Experience has shown that they may be grown successfully on land too poor for successful crops of cotton or maize,

[1] Delaware Sta. Bul. No. 46 (1903), p. 4.

the failure of the soil to produce the latter crop being due, doubtless, to a lack of available nitrogen.

The Arkansas Station found as the result of five years' trial with ten varieties that the best results were obtained in seasons of least rainfall, as follows:

Influence of Rainfall on Yield of Cowpeas

Year	Rainfall inches	Hay per acre, lb.	Peas per acre, bu.
1898	62.2	3,268	12.3
1899	36.3	3,054	13.7
1900	32.7	2,781	21.3
1901	22.2	3,873	28.4
1902	37.2	3,042	13.4

In rainy seasons the plant suffered from mildew, which decreased the yield of peas, and to a less extent the yield of hay.[1] While cowpeas may be grown in Canada, their climatic adaptation is south of the latitude of St. Louis. They appear to require warmer soil and atmospheric conditions for successful germination and early growth, but will withstand fall frosts better than field beans. Some varieties will remain green all winter in portions of the Gulf states, and thus furnish winter pasture.

308. Inoculation.—Cowpea roots almost universally bear root-tubercles without artificial inoculation. Under field conditions, the Alabama Station found no increase from inoculation, since the roots developed an abundance of root-tubercles without inoculation.[2] The New Jersey Station, however, found that the first season there were few root-tubercles, but that they increased each season for three years when they were abundant. The growth of forage increased with the increase in the abundance of root-tubercles.[3]

[1] Arkansas Sta. Bul. No. 77 (1902), p. 32.
[2] Alabama Sta Bul. No. 87 (1897), p. 480.
[3] New Jersey Sta. Rpt. (1899), p. 200.

A low and irregular yield of cowpeas in 1899 was attributed by the Arkansas Station partly to the unimproved condition of the soil, and partly to the absence or limited number of tubercle-producing organisms in the soil.[1] At the Delaware Station plants grown in sterilized soil produced no tubercles, and made a weak growth.[2] Under favorable conditions, tubercles develop when plants are only a few inches high.

309. Rotations.—On account of the ease and variety of conditions under which different varieties will grow, and the rapidity with which they will develop, cowpeas are admirably adapted to simple or elaborate rotations. (C. A. 396) They are usually planted in the southern states between the maize rows at the last or next to the last cultivation, or follow oats, wheat, or rye as a second crop, thus adding to the number of crops which may be taken from the land during a rotation. A desirable rotation for the cotton states is: maize and cowpeas, one year; oats followed by cowpeas harvested for hay, one year; cotton one or two years. In the more closely and thickly planted maize fields of the North Atlantic and the North Central states cowpeas do not develop sufficiently to be of value either for forage or for fertilizers.

310. Fertilizers.—In general, nitrogen has not been found a profitable constituent of fertilizers for cowpeas. The Alabama Station, however, found on a soil previously liberally fertilized with phosphates and potash an increase of about four bushels of seed or about 27 per cent. from the use of complete commercial fertilizer, with practically no increase from mineral fertilizers. In another experiment there was an increase of 4.5 bushels or 48 per cent. from the use of 240 pounds of Florida soft (rock) phosphate per acre, and an increase of 5.8 bushels or 60 per cent. from the same quantity of acid phosphate.[3] The Tennessee Station found that nitrate of soda had apparently no effect on the growth and yield of the crop, while muriate of potash and lime used singly increased the green yield about one ton per acre. The experience of this station has been that acid phosphate used alone has given

[1] Arkansas Sta. Bul. No. 70 (1901), p. 93.
[2] Delaware Sta. Rpt. (1896), p. 108.
[3] Alabama Sta. Bul. No. 118 (1902), p. 21.

the most profitable returns.[1] Connecticut Storrs Station[2] also found after twelve years' experience only mineral fertilizers could be profitably used in growing the crop for forage or for green manure.

The Alabama Station[3] conducted two experiments on the effect of lime on cowpeas, using the variety Wonderful. The cowpeas were seeded with a drill, fertilized with acid phosphate, and cultivated several times. In one test, on reddish loam soil, the yield was 5.6 bushels of peas without lime, and 5.2 bushels where slaked lime at the rate of 640 pounds per acre had been applied broadcast in February of the preceding year. In the other test, on gray sandy soil, water slaked lime at the rate of 1,000 pounds per acre of unslaked lime was used as a top dressing on oats. The oat stubble was plowed and seeded with a drill to cowpeas. On the plot not limed the yield was 13 bushels of cowpeas per acre, while the limed plot yielded 10.2 bushels per acre. There was no notable difference in the appearance of the vines.

311. Time of Seeding.—The time of seeding will vary with the latitude, the variety, and the purpose for which the crop is to be used. Where grown for seed, seeding should occur later than for hay, since late planting tends to produce a more erect habit and hence greater seed production. Early planting promotes a luxuriant growth of vines. In the regions north of the cotton belt, planting may occur after maize has been planted or about the time of common field beans. In the cotton states, planting may occur between April 1 and August 15, but May, June, and the first half of July are the best months. For seed production, June is the best month.

The Delaware Station[4] planted cowpeas at intervals from May 18 to July 25. The seedings of the latter part of June and of early July were the most profitable. The Alabama Station planted New Era cowpeas (an early maturing variety) on April 26, picked seeds July 22, planted these seeds July 26, which produced a crop of seeds before frost, 90 per cent. of the pods being ripe on November 1.[5] Cowpeas sown in Arkansas in May, June, and July produced twice as much hay and three times the quantity of peas as when sown in August. The Arkansas Station, however, believes it usually profitable in that latitude to sow as late as August 15.[6]

[1] Tennessee Sta. Bul. Vol. XIV. (1902), No. 1, p. 16.
[2] Connecticut Storrs Sta. Rpt. (1901), p. 138.
[3] Alabama Sta. Bul. No. 118 (1902), p. 20.
[4] Delaware Sta. Rpt. (1895), pp. 232-6.
[5] Alabama Sta. Bul. No. 118 (1902), p. 6.
[6] Arkansas Sta. Bul. No. 70 (1901), p. 123.

312. Quantity of Seed.—The amount of seed used in ordinary practise varies from less than one peck to three or more bushels per acre. A greater quantity is used for hay than for seed, and for late than for early planting. The size which the plant attains, the size and germinating ability of the seed, the fertility of the soil, and the manner of seeding enter into the problem. It is a practise with some, where the germination is as low as 50 per cent., to double the quantity of seed. Since germination is affected largely by stage of maturity, weather, and method of handling, it is usually good economy to grow one's own seed. In heavy soils, poor stands are not infrequently due to a crusting of the surface that prevents the plants from coming up. Other things equal, the richer the soil and the better the seed-bed, the less the seed required.

The Arkansas Station in one trial with Whippoorwill sown May 4 at one, two, three, four, six, and eight pecks, obtained a yield of 3,314 pounds of hay and 31.4 bushels of peas when one peck of seed was used, the yield of both hay and peas decreasing with each addition of seed, eight pecks of seed producing 1,749 pounds of hay and 16.4 bushels of peas. On May 20 a series of plats was sown with quantities of seed varying from 12.5 to 100 pounds per acre. The largest yield of hay, 2,675 pounds, and the largest yield of peas, 36 bushels, were obtained from the smallest seeding, but the decrease in yield from the thicker seeding was not uniform. The largest seeding produced 2,275 pounds of hay and 20 bushels of seed per acre.[1] The Illinois Station reports that the New Era cowpea was planted in rows three feet apart with the following yield of peas: 3 inches apart in the row, 27.5 bushels; 6 inches apart, 32.5 bushels; 9 inches apart, 42.5 bushels per acre.

In a favorable season the Delaware Station[2] planted on June 7 Whippoorwill seed at the rates of one, two, three, four, and five pecks per acre. The yields on all plats were practically the same for both vines and peas, except where one peck was sown, in which case the yield of vines was considerably below the average. The Mississippi Station[3] secured from 60 pounds of seed per acre 2,520 pounds of hay per acre, and from 30 pounds of seed 2,440 pounds of hay per acre.

313. Mixtures.—The need of some grass to grow with cowpeas for hay in order to assist in handling and curing peas has

[1] Arkansas Sta. Bul. No. 70 (1901), p. 99.
[2] Delaware Sta. Bul. No. 46 (1900), pp. 23, 24.
[3] Mississippi Sta. Bul. No. 83 (1904).

been suggested. Volunteer crab grass (*Panicum sanguinale* L.) often serves a useful purpose, but the irregularity of the stand and the size of plants are an objection. Millet can be sown with early maturing varieties, using one peck of millet seed to one bushel or less of cowpeas. At the Alabama Station drilling Amber sorghum and Wonderful peas together, on May 14 increased the yield of hay materially, but did not decrease the difficulty of curing.[1]

314. Methods of Seeding.—There are many methods of sowing cowpeas. When grown in maize, the seed may be sown broadcast just before the last cultivation, which operation covers it; or immediately after the last or next to the last cultivation, a single row of cowpeas may be drilled with the one-horse cotton or maize drill. Sometimes a furrow is opened with a shovel plow, the seed sown by hand, and then covered by cultivating each side and throwing the earth over the seed.

The Arkansas Station compared drilling with planter with broadcasting, using 30 pounds of seed per acre in each case, and obtained 11.4 bushels of peas and 1,498 pounds of hay by drilling, and 6.1 bushels of peas, and 1,264 pounds of hay by broadcasting.[2] When sown alone, for example after a crop of oats, the seed is sometimes sown broadcast before plowing, using 60 to 90 pounds of seed per acre. A better method is to plow first, and, if sown broadcast, to cover with the disk harrow, since moderately deep covering is desirable. If for hay, and if a grain drill is available, close every other outlet so that the rows will be 14 or 16 inches apart, using 20 to 40 pounds of seed per acre; if for seed, close enough outlets to make the rows 32 to 40 inches apart, using 10 to 20 pounds of seed per acre. The one-horse maize planter is also widely used, making rows preferably 36 inches apart. (C. A. 305)

315. Cultivation.—In practise cowpeas get very little cultiva-

[1] Alabama Sta. Bul. No. 118 (1902), p. 29.
[2] Arkansas Sta. Bul. No. 70 (1901), p. 104.

tion. By cultivation, however, the Arkansas Station has obtained increased yields of peas, ranging from 50 to 100 per cent. If sown between maize rows, they and the maize may and may not get a cultivation after cowpeas are planted. When sown alone for hay, pasture or fertilizers, no cultivation is ordinarily received or required. When planted for seed, they may be cultivated as for field beans or maize, about two cultivations being generally sufficient. For clean culture, one hoeing is generally necessary, although this operation is usually looked upon as unprofitable. Attempts are made to avoid this by using the weeder after the plants have developed several leaves and the stems have become toughened.

In view of the danger of fungous diseases, this practise is questionable, even where the soil is such as to make the weeder otherwise practicable. The young plants are, like all beans, tender and easily broken, requiring careful cultivation. Cultiation should not occur when plants are wet, for reasons given under field beans. (268) Cultivation should cease with the first appearance of pods, when the crop is intended for hay, since cultivation tends to prolong the period of growth, and hence to make curing more difficult.

316. Insect Enemies.—The cowpea is subject to the attack of the common bean weevil (271), but is more frequently attacked by the Chinese cowpea weevil (*Bruchus chinensis* L.) and the four-spotted bean weevil (*B. quadrimaculatus* Boh.), both of which appear to be specific enemies of the cowpea. They are generally distributed in the South, and are increasingly injurious with the increased area devoted to cowpeas. The size and life history of both species are similar to that of the bean weevil; hence their injury and the remedies therefor are similar. The firefly (*Lampyridae*) was observed by the Louisiana Station[1] to visit frequently cowpea flowers, which subsequently failed to produce fruit. Since the percentage of fructification was higher in plants which had been covered than in those exposed, it was believed that the firefly was largely responsible.

317. Diseases.—The cowpea is subject to two serious diseases, the cowpea wilt (*Neocosmospora vasinfecta*, var. *tracheiphila*

[1] Louisiana Sta. Bul. No. 40 (1896), p. 1448.

Erw. Sm.), and the root-knot (*Heterodera radicicola* (Greef.) Müll.). Both occur most commonly on sandy soils, and are likely to occur together. The Iron cowpea is recommended by the United States Bureau of Plant Industry as resistant to both diseases. The variety, however, is rather late in maturing, and not especially prolific in seed. The cowpea wilt does not attack other plants; hence growing other crops for two years will give temporary relief. The same nematode worm produces root-knot on other plants; such as, cotton, okra, peaches, and certain garden vegetables. Rotation of crops is, therefore, less effective; but assuming Iron cowpea not to be attacked by this disease, the following rotation of crops is recommended: first year, maize with Iron cowpeas between the rows; second year, oats followed by either beggar weed, velvet bean or Iron cowpeas; third year, and, if necessary, fourth year, cotton.[1]

Healthy and diseased roots of cowpea. The diseased roots on the left show tufts produced by the wilt fungus.
(After Orton)

318. Wilt.—Infection occurs by the spread of the mycelium through the soil. The fungus finds entrance to the plant through the small roots, develops in the water ducts of stem, small branches, and petioles of leaves. Though the mycelium is white, its destructive work imparts a brown color to the wood. The abundant hyphal growth in the water vessels shuts off the water supply of the plant, and within a day or two after the brown color appears the plant dies.

319. Root-knot, also known as root-gall, enters the roots of cowpeas, producing by irritation of plant-cells swollen, bead-like tumors on the roots. It attacks both tap and lateral roots. The forms of the galls vary; the surface is at first smooth, then cracked, scurfy, and more or less decayed. The eggs hatch in the tissue of the old gall from which the nematodes force their way into fresh parts of the same root or find their way out into the soil where they hunt a new root in which to take up existence. The number of nematodes

[1] U. S. Dept. Agr., Bu. Pl. Ind. Bul. No. 25 (1905), p. 67.

determines the size of the gall, the hatching of eggs and spread of new uematodes increasing the size. The galls resemble the swellings caused by clubfoot in cabbage, from which they may be distinguished in cross-section under the microscope by eggs, larvae, or cysts of the nematodes in some stage of development. The life cycle is said to require about one month.

320. Collateral Reading.—Alva Agee: The Cowpea in the North. Pennsylvania State Dept. Agr. Bul. No. 130, 1904.

North Carolina Horticultural Society: The Cowpea. Experiment Farm, Southern Pines, N. C.: The Society.

F. Lamson-Scribner: Southern Forage Plants. U. S. Dept. Agr., Farmers' Bul. No. 102 (1899), pp. 33-7.

Jared G. Smith: Cowpeas. U. S. Dept Agr., Farmers' Bul. No. 89, 1899.

C. L. Newman: Cowpea Experiments. Arkansas Station Bul. No. 77, 1903.

J. F. Duggar: Cowpea Culture. Alabama Station Bul. No. 118, 1902.

J. B. Killebrew: Grasses and Forage Plants. Tennessee Station Bul. Vol. XI (1898), Nos. 2, 3, and 4, pp. 95-99, 108-111.

XIV

LEGUMES FOR SEED

I. COWPEAS

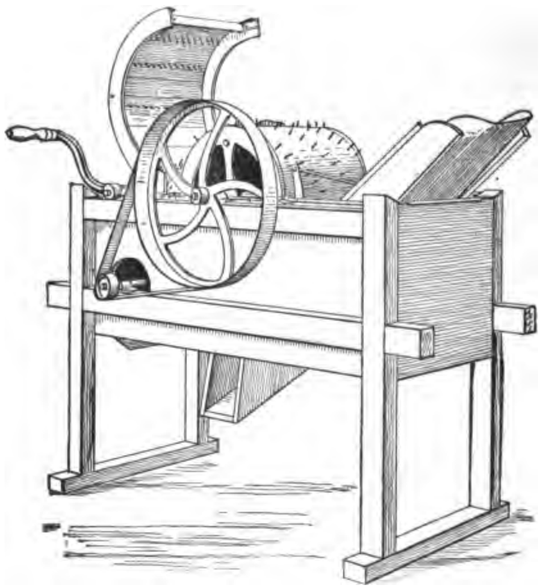
321. Time of Harvesting.—When picked by hand for seed, the crop may be harvested when the pods and seeds have become thoroughly mature. If vines are harvested primarily for the seed, cutting before thoroughly dry will prevent loss of seed, and in some cases loss from mildew on pods, which not infrequently occurs when left to ripen for hand picking.

The Arkansas Station has shown that success in curing cowpea hay depends largely on the stage of maturity. Varieties representing five seasons of growth were planted June 9, and subsequently cut at four stages of maturity as follows: (1) when first pods had formed; (2) first pods ripe; (3) half the pods ripe; (4) all the pods ripe. The following table shows the varieties used and their season of maturity:

Influence of Stage of Maturity on the Curing of Cowpea Hay

Variety	Season of maturity	Date of ripening first pods	Time required to ripen first pods, days
Warren's New Hybrid . .	Very early	Aug. 15	67
Warren's Extra Early . .	Early	Aug. 20	72
Whippoorwill	Medium	Aug. 28	80
Taylor	Late	Sept. 8	90
Clay	Very late	Sept. 14	97

Mowing when the first pods were forming resulted in the very early, early, and medium varieties curing into indifferent, moldy, and slightly rotten hay; while the late and very late varieties cut at the same stage of maturity rotted before the vines could become hay. The early varieties cut when the first pods were ripening cured into very fair hay, but the late varieties rotted and molded. Good hay was obtained from mowing the late variety (Taylor) when the pods were half ripe, but the very late variety (Clay) made only indifferent hay when



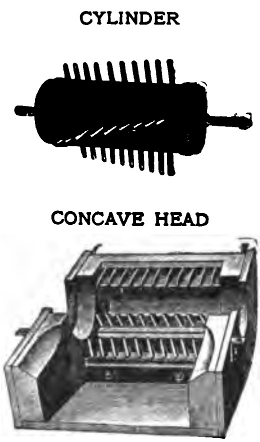
Cowpea huller with hulling cylinder exposed
(From photo by Thompson)

the pods were all ripe. During five years with a large number of varieties, but few have been successfully converted into hay when mown in vigorous growth. On the other hand a number of varieties have been cured in good condition when cut fully ripe, even after having lain in the field through several days of rain and little sun.[1] The South Carolina Station found that

[1] Arkansas Sta. Bul. No. 80 (1903), p. 75.

cowpea vine hay increased in protein from the stage of full bloom and reached its maximum when peas were formed.[1] Although varying with the variety and the weight of the crop, on the whole, the best time to cut for hay is when seeds are well formed and the leaflets and pods have begun to turn yellow.

322. Method of Harvesting.—When cowpeas are sown in the maize at the time of "laying by" they are usually not harvested for hay, on account of the difficulties necessarily involved, although occasionally they are pulled by hand. Ordinarily men and boys pick the ripened pods and place them in sacks. Sometimes on account of the differences in time of ripening a field is gone over twice in this way. The pods are left in the sacks until threshed. If in small quantities, hulling or threshing is done with a flail and cleaned with a fanning mill; with larger quantities the cowpea huller is used. If planted in drill rows three feet apart, upright varieties could without doubt be successfully harvested with the bean harvester (269) and the whole plant, when properly cured, threshed in an ordinary grain thresher. Such practise is not common, due doubtless to the fact that cowpeas planted between rows of maize are ample to furnish seed required.



Parts of a cowpea huller

Those varieties which produce the largest yield of vines are those in which the trailing habit is most pronounced. and consequently offer the greatest difficulty in harvesting. Generally, however, the ranker growing varieties are used as soil renovators and for pasture; while bush varieties are recommended

[1] South Carolina Sta. Rpt. (1899), p. 170.

for hay because they are more easily cut, handled, and cured. and hold their leaflets better. Usually the scythe or mowing-machine is used, but difficulty is experienced in cutting the mass of trailing and tangled vines. So far as the writer knows, the pea harvester used commonly for harvesting field peas in Canada has not been tried. (281)

323. Curing Hay.—Although the principles are the same, curing cowpeas is more difficult than red clover or alfalfa. Handling the crop before the leaflets become brittle is essential. According to the Alabama Station the leaflets constitute 30 per cent. of the weight of hay, and are about twice as high in protein as the other portion of the plant. With different varieties from 51 to 75 per cent. of the weight of the entire plant was obtained in hay, the remainder being in roots, stubble and fallen leaves (leaflets). When stored in a tight place in a half-cured condition, as sometimes recommended, fermentation and rotting were excessive and the product unsatisfactory. Wilting, placing in small cocks and covering with hay caps produced good results and the method is recommended as economical.[1]

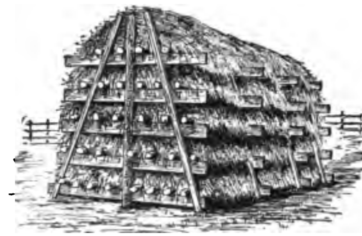
The Mississippi Station[2] has found the following a practicable method of curing hay: The crop being mown in favorable weather in August or September, the vines are raked up the same or the following day, and put into cocks of the size that two men can handle with a fork when cured. The hay is left in the cocks for four or five days, meanwhile being turned over once or twice, then hauled to the barn or put into a stack. When put into stacks the sides of the latter are built straight up, while a good covering of grass is used. When harvesting falls in rainy weather the vines are left to cure on the ground, when they are hauled directly to storage.

For storage, rail pens made of ten-foot rails are often used. After filling in three or four feet of cowpea hay, a layer of rails is put across when another quantity of hay is added, followed by a layer of rails, and so on until a height of ten or twelve feet is reached. The pen is then roofed over with straw, hay, sorghum, or other cheap roofing. In feeding, two or three rails are removed so that the live stock can feed upon the first layer; when this has been eaten a layer of rails is removed and hay allowed to settle down where live stock can reach it.

[1] Alabama Sta. Bul. No. 118 (1902).

[2] Mississippi Sta. Bul. No. 84 (1904), p. 16.

324. Production and Yield.—From the census it appears that in 1899 about six million bushels of seed were raised with an average yield of about eight bushels per acre. At the Alabama Station 28 varieties ranged, during four years, from 7 to 23 bushels of seed, and 17 varieties, during three years, ranged from three-fourths to two tons of hay per acre. In a series of fertilizer tests the yield of seed per acre was about 16 bushels.[1] Twenty-one of the 46 best varieties of cowpeas tested at the Georgia Station yielded green vines ranging from 9 to 12 tons per acre, and seed varying from 25 to 42 bushels per acre.



Frame for curing cowpea hay. The frame consists of a series of open shelves one above the other. Rails or poles placed 12 inches apart form the shelves; the horizontal supports are far enough apart to make the shelves 2 feet apart. Upright posts with one end securely in the ground carry the horizontal supports. The diagonal braces are 1 x 4 inches.

At the Arkansas Station with the rows 3.5 feet apart, the yield of peas ranged from 40 bushels to nothing, while the yield of hay ranged from 8,700 to 700 pounds, not including the peas. Where 8,700 pounds of hay were produced the yield of peas was in addition 2.1 bushels (Whippoorwill), while where the 700 pounds of hay were produced the yield of peas in addition was 22.3 bushels (New Era).[2] During five years varieties well suited to the production of hay have yielded well above two tons per acre, not including peas and hulls, and when the peas were harvested with the vines the average has been approximately three tons per acre.[3] At the Illinois Station the best ten varieties averaged 26 bushels of peas to the acre.[4]

[1] Alabama Sta. Bul. No. 118 (1902), pp. 13, 18, 20.
[2] Arkansas Sta. Bul. No. 77 (1903), p. 29.
[3] Arkansas Sta. Bul. No. 80 (1903), p. 70.
[4] Illinois Sta. Circ. No. 69 (1903), p. 5.

325. Use.—As forage either green or dried, it is readily eaten by cattle and sheep. The dried forage is similar in composition and digestibility to alfalfa hay, and has been found especially valuable for milch cows, reducing the amount of bran and other concentrates required in the ration. (230) It makes an excellent pasture for swine, but is less desirable for cattle and sheep on account of its liability to produce bloat. The seeds, either green or dried, are for domestic uses, when cooked, equal in taste and nutritive qualities to field beans, and may be fed to all classes of live stock without cooking, for which they have high value. The Tuskegee Station has prepared and tested 25 receipts for cooking the dried and green seeds and the green pods, including soups, salads, fritters, and griddle cakes. The roasted seeds are a substitute for coffee.[1]

Since the whole plant has a high feeding value, there is no need of separating the seed when feeding to domestic animals. During three years the Alabama Station compared the yield of seed and of hay made by Wonderful cowpeas, obtaining 510 pounds of peas and 3,608 pounds of hay.[2] Since well-cured cowpea hay is in composition, digestibility, and feeding value similar to wheat bran, hay rather than seed production is most profitable. The office which the plant performs in protecting bare land and in renovating soils by supplying both humus and fertilizing constituents is far-reaching.

326. Value.—The cowpea has many points which make it a valuable cultivated crop: it furnishes palatable and nutritious food for both man and domestic animals; it will give a satisfactory yield over a wide variety of soils and conditions of soil; it is easily grown and at comparatively little expense; the seed can readily be produced on farm, at least seeming to reduce the cost of seed; it fits into crop rotations; it universally produces an abundance of root-tubercles, and has undoubted value

[1] Tuskegee Sta. Bul. No. 5 (1903), p. 10.
[2] Alabama Sta. Bul. No. 118 (1902), p. 31.

in soil improvement not only from what the harvested crop leaves upon the soil, but also from the character of the manure produced when the crop is fed. Aside from diseases and insect enemies, its one great drawback is the difficulty of harvesting the crop, whether for seed or for forage.

"An enormous increase in the acreage of cowpeas would do more, we think, than any other immediately practicable reform to cure the ills of southern farming, to enrich the soil, to raise the acreage yield of all other crops, to build up the live stock industries, and to promote diversified farming."[1]

327. Feeding Value.—The cowpea is especially rich in protein, hence a desirable feeding stuff. While it makes an excellent silage readily eaten by live stock, the great difficulty is in preserving it. When so used it has been found to be good practise to grow the peas with maize in order to facilitate the process of ensilaging and to enhance its keeping qualities. Silage of this sort is reported to contain from 10 to 25 per cent. of protein. Maize and cowpea silage was found by the Kansas Station[2] to be more profitable than growing these two crops together either for forage or for pasture.

At the Oklahoma Station[3] shoats weighing 115 pounds were divided into two lots. Lot 1 was fed a mixture of kafir corn meal and maize meal, taken in equal quantities, and in addition, cowpea hay *ad libitum*. Lot 2 was fed only the grain mixture. For each pound of gain, lot 1 consumed 4.75 pounds of grain; while lot 2 consumed 8.2 pounds of grain for each pound of gain. In another trial this station found that cowpeas seven weeks old on wheat stubble furnished good cow pasture, that after being eaten low, and the cows taken off, the second growth furnished equally good grazing.[4]

The Alabama Station[5] made two tests, each 30 days in length, of substituting cowpea hay for wheat bran in a ration for milch cows. The results showed the average cost of food for one pound of butter to be 12.3 cents with the cowpea ration, and 15.9 cents with the wheat bran ration. The cowpea ration showed a saving of 23 per cent. in cost of food per pound of butter when wheat bran cost $20 per ton. It was shown in the tests that a ton of cowpea hay was equal in feeding value to 86 per cent. (1,720 pounds) of a ton of wheat bran.

The Maryland Station[6] obtained better results with cowpea silage than with either cowpea hay or maize silage. When maize silage was fed with cowpea silage, equal parts by weight, the yield of milk was greater than when cowpea hay was fed, but less than when cowpea silage alone was fed.

[1] Alabama Sta. Bul. No. 118 (1902), p. 6.
[2] Kansas Sta. Bul. No. 123 (1904), pp. 220-8.
[3] Oklahoma Sta. Rpt. 1899-1900, p. 48.
[4] Oklahoma Sta. Bul. No. 48 (1900), p. 10.
[5] Alabama Sta. Bul. No. 123 (1903).
[6] Maryland Sta. Bul. No. 98 (1904), pp. 63-72.

The New Jersey Station[1] compared 17 pounds of cowpea hay with a grain ration of the following weights: wheat bran 4, dried brewers' grains 3, and cotton seed meal 2 pounds, 36 pounds of maize silage being fed with each ration. The experiment was conducted with four cows and continued for 36 days. The result showed a gain of 8.3 per cent. more milk and 15.2 per cent. more butter from the grain ration, all the cows testing higher in butter fat when fed grain. On the other hand, one hundred pounds of milk cost 39.8 cents, and a pound of butter 8.82 cents when the cowpea ration was employed, while the respective costs were 60.5 cents and 12.06 cents with the grain ration. Other experiments showed cowpea hay to be equal in feeding value to alfalfa hay, while crimson clover hay was less valuable. Cowpea silage, with alfalfa or with crimson clover hay, was not equal to maize silage with alfalfa hay.

The Tennessee Station[2] conducted a feeding experiment with milch cows for 120 days. Twelve cows, divided into three groups of four each, were employed. The rations were fed in two equal parts, and in proportion to the live weight of the animal. Silage (30 pounds in each ration) was the principal roughage employed, though cowpea hay was also regarded as such. To determine the relative efficiency of protein in cotton seed meal, cowpea hay and wheat bran, 4 pounds of cotton seed meal and 6 pounds of wheat bran were fed in group 1; 4 pounds of cotton seed meal and 7 pounds of cowpea hay in group 2; and 6 pounds of wheat bran and 13 pounds of cowpea hay in group 3. The cowpea hay was fed in a finely cut condition. It was the aim, in the substitution of this hay for cotton seed meal and for wheat bran, to maintain the relative proportion of protein in each ration. The amount of dry matter consumed for the production of a gallon of milk was 6.2, 6.5, and 7.2 pounds with groups 1, 2, and 3, respectively; per pound of butter produced, the digestible matter consumed was 12.7, 12.3 and 13.1 pounds with groups 1, 2, and 3. Group 2 consumed the largest amount of the protein for 1,000 pounds of live weight and made the cheapest gallon of milk, 5.2 cents, and the cheapest pound of butter, 9.9 cents. Group 3, which consumed the smallest amount of dry matter, produced a gallon of milk at a cost of 6 cents, and a pound of butter at a cost of 10.9 cents. Group 1 produced a gallon of milk at a cost of 5.9 cents, and a pound of butter at a cost of 12.2 cents.

328. Acquirement of Nitrogen.—The Storrs (Connecticut) Station found that cowpeas grown in sand and supplied with nutritive solutions including nitrogen gained considerably in nitrogen when root-tubercles were present.[3] By means of box

[1] New Jersey Sta. Rpt. 1903, pp. 388-396.
[2] Tennessee Sta. Bul. 15 (1902), No. 4.
[3] Connecticut Storrs Sta. Rpt. 1891, p. 17.

experiments, the New Jersey Station concluded that in two years the gain of nitrogen to the soil in which cowpeas grew was equivalent to an increase of 1,600 pounds of nitrogen to an acre one foot in depth. This was not all due to the cowpeas, but in part to processes within the soil itself.[1]

The Delaware Station reports that a maximum crop of alfalfa yielded 1,230 pounds (200 pounds of nitrogen) of protein per acre, while maximum crops of cowpeas and crimson clover yielded about 725 pounds each of protein (115 pounds of nitrogen) per acre. Since, however, a crop of crimson clover and of cowpeas may be grown from the same land in one season, these crops are recommended where alfalfa fails to thrive.[2] The Alabama Station found in the entire growth of cowpeas in an average of three cases 70 pounds of nitrogen per acre, 28 per cent. of which, or 20 pounds, was in the roots, stubble, and fallen leaflets.[3]

Influence of Cowpeas and Velvet Beans on Succeeding Crops

Crop	From plowing in whole plant of cowpeas and velvet beans, except pods of cowpeas		From plowing in roots and stubble of cowpeas and velvet beans	
	Increased yield lb.	Increased yield per cent.	Increased yield lb.	Increased yield per cent.
Seed cotton	567	63	208	18
Maize, grain	413	81	241	32
Oats, grain	544	189	496	334
Wheat, grain	339	182	402	215
Sorghum, hay	4,200	78	4,160	57

[1] New Jersey Sta. Bul. No. 180, p. 37.

[2] Delaware Sta. Bul. No. 55, pp. 3-8; Rpt. 1901, pp. 8-13

[3] Alabama Sta. Bul. No. 120 (1902), p. 123.

(3) The field may be grazed and the remaining stubble and the added manure subsequently plowed under.

(4) The crop may be mowed for hay and the stubble only plowed under.

Which of these methods will be best will depend somewhat on the character of the soil, the amount of live stock available, and the system of farm management. On heavy clay soils the plowing under of a large growth of green cowpeas may be desirable when on a light, sandy soil it might make the soil temporarily too loose. Leaving a crop to decay on the surface may be desirable where the soil is sandy and liable to wash during the winter.

331. History.—The cultivation of cowpeas by the orientals dates back into centuries. The plant was used for forage for domestic animals while its seeds became an article of human diet. It was introduced into the southern states of North America by a South Carolina planter who obtained a small quantity of seed from the captain of a trading vessel from India or China early in the eighteenth century.

II. SOY BEAN

332. Description.—The soy bean is an upright, rather woody annual, growing two to three, rarely four feet high. The three large leaflets, often six inches long and four inches wide, are borne on leaf stalks not uncommonly 10 to 12 inches in length, giving the plant the appearance of being much branched. The leaflets are a large part, and the most valuable part of the whole plant when used for forage, and are liable to be lost in curing for hay. The small, inconspicuous lilac or violet flowers are borne in the axils of the leaves, and are self-pollinated. The pods are said to be two to five-seeded. Pods with more than three seeds are, however, exceedingly rare. Haberlandt reports that plants grown in Austria-Hungary bore about 200 pods and 450 seeds each. The valves of the pods twist as they open, which occurs very readily when pods ripen, thus causing loss of seed.

The seeds are globular, more or less compressed, and vary in color from nearly white to black, varieties being usually divided according to the color of their seeds into three groups: white, green, and black. The seeds vary greatly in size. A sample of Early Green contained 3,135 seeds, and of Early Black 1,460 seeds per pound. This plant is characterized by the abundance of the conspicuous reddish-brown hairs which cover all parts of the plant, especially the stems, leaf stalks, and pods. It has a stout tap root; but in general, the root growth is rather light.

Medium Early Green soy bean
(From photo by Gilmore)

333. **Varieties.**—Although there is a number of varieties, the soy bean appears much less variable than cowpeas. Varieties, in addition to the color of the seed, are classified according to the time of maturity into early, medium early, medium, medium late, and late. The earlier varieties are smaller, and usually produce more seed in proportion to the size of the plants. For the successful culture of soy beans, it is quite as important to plant the variety suited to the climate and other conditions of culture and use as it is in the culture of maize. Perhaps as a better knowledge of the adaptation of several varieties is obtained, the cultivation of the plant will become more extended.

"The 'Early White' soy bean is an excellent variety to grow when a crop of seed is desired, particularly in the North, where the growing season is likely to be short. It is not a good variety to grow for hay or soiling, however, on account of the small size of the plants and a tendency to drop the leaves early. 'Medium Early Green' is one of the best varieties to plant for hay, as it yields heavily and retains its leaves well. For soiling or for ensilage 'Medium Early Green,' 'Medium Early Black,' or the 'late' green or black varieties may be used, according to the length of the season and the time at which the crop is to be used. In the New England states the 'Medium Early Green' variety is generally preferred, while in the Central states 'Medium Early Black' seems to be the favorite. In the South the 'medium' or 'late' varieties are used, some preferring one and some another. For green manuring the large, medium or late varieties are best, 'Medium Late Black' being excellent for this purpose."[1]

334. Distribution.—In oriental countries the use of legumes or pulses of many kinds as human food is much more common than in Europe and America, which, in connection with fish and poultry, accounts for the less extensive use of red meat among orientals. The soy bean is one of the most extensively used of these legumes, especially in Japan, where many preparations are made from it, it being seldom, if ever, used alone as a vegetable. It has been introduced into Europe, and in 1878 Haberlandt published results of experiments strongly urging its cultivation as a food plant for both man and domestic animals. It was introduced into the United States in 1854 without attracting wide attention until recent years, when many new varieties have been introduced, chiefly through the efforts of the Massachusetts and the Kansas stations, which have experimented with this crop quite extensively.

At least 31 stations in the United States and Canada have studied this plant, and most of them have reported more or less favorably. It has also been widely tried by farmers throughout the United States, but never extensively grown. While it is a plant of undoubted value, under present economic conditions it does not seem destined to equal in importance cowpeas, field peas, or field beans. Whether grown for seed or for forage, in practise the yields have been disappointing, although excellent results have been obtained at experiment stations. The Illinois Station reports, with six maturing varieties, yields of seed ranging from 28 to 42 bushels per acre.[2] When grown for forage, it is difficult to cure properly, and when grown for seed it is difficult to harvest without loss of seed.

[1] U. S. Dept. Agr. Farmers' Bul. No. 58, pp. 6, 7.

[2] Illinois Sta. Circ. No. 69, p. 7.

335. Adaptation.—The soy bean has a soil adaptation similar to that of the common field bean, and a climatic range and adaptation similar to that of maize. In general, the soy bean finds its best adaptation south of the climatic range of field beans and north of that of the cowpea. It is less easily injured by frost, and can endure dry weather better than the field bean. Soy beans will grow, however, on soils too sandy and poor for field beans, and are adapted to the improvement of such soils when properly inoculated. At the Vermont Station cowpeas yielded less than half as much dry matter, and less than two-thirds as much protein as the soy bean.

Root tubercles on soy bean
(After Moore)

Soy beans are characterized by the large and abundant root-tubercles, which the tap and branch roots bear when soil is properly inoculated, especially in sandy soils comparatively deficient in available nitrogen, and under such circumstances are characterized by the increased vigor and size of inoculated compared with uninoculated plants. Practical experience has shown that this plant is less likely, when introduced into a new region, to find in the soil the proper organisms for the formation of root-tubercles. The inoculation of the soil with soy bean root-tubercle bacteria when the plant is first introduced is, therefore, of the highest importance.

336. Seeding.—While more variation in the time of planting is possible, in general, the conditions most favorable to maize are also favorable to soy beans. It is better to plant later than maize rather than earlier. When grown for seed, planting in drill 28 to 36 inches apart as in the case of field beans, using seed enough to obtain about six plants to each foot, is recommended. The amount of seed required will depend on the size of the seed and the favorableness of the conditions for germination. Usually about one-third of a bushel will be sufficient. Soy beans require plenty of room for their best development, and should not be planted too thickly for seed. For the production of hay, they should be planted somewhat more thickly, because they will be cut when less mature. While they may be sown as in the case of wheat and oats, probably the best method is to close every other outlet to the grain drill so that the drill rows will be 14 or 16 inches apart, using two-thirds to one bushel of seed per acre. If sown broadcast, one and a half bushels per acre will be required. In the southern states, soy beans may be sown, as is common with cowpeas, between the rows of maize at the last cultivation. In the northern states farmers occasionally plant soy beans in the same hill and at the same time with maize intended for silage. Without reducing the number of grains of maize per hill, it is customary to add six to ten soy beans. A hand planter with two hoppers has been made so as to drop maize and soy beans in the same hole.

337. Cultivation.—Under favorable conditions, soy beans come up quickly and grow rapidly, soon shading the ground and making but few cultivations necessary, assuming them to have been planted far enough apart to cultivate. When the beans first appear above ground, the young plants are tender and easily broken, but after several leaves have been formed, a weeder may on some soils be used, even when sown for hay. Cultivation should not be given when the leaves are wet, for reasons given under field beans. (268)

338. Insect and Other Enemies.—So far as reported, the plant has no special insect or fungous foes. It has been known to be attacked by grasshoppers, a caterpillar and a leaf-miner, and the underground parts of the stem by the bean root-louse (*Tychea phaseoli* Passerini), but none of these has assumed economic importance.[1]

339. Harvesting.—If for dry forage, the crop should be cut when the pods begin to form; if for silage, the pods may be allowed to become somewhat more mature; while, if cut for seed, one-half or more of the pods should be mature. If the pods become too mature, they will burst open, and much of the seed will be lost even before the plants are harvested.

For hay, or silage, soy beans may be harvested with the mowing-machine, although the woody stems are rather difficult to cut. Large varieties may be successfully cut and bound with a maize harvester, and cured into hay in shocks. Usually the curing is similar to that of alfalfa, or clover, but is more difficult on account of the large leaves, which are easily lost in curing. For seed, the bean harvester may be used. The ordinary threshing machine can, by adjusting or removing the concaves, be used satisfactorily, although the bean thresher may be preferable. In small quantities, they may be pulled by hand and threshed with a flail, both operations being comparatively easy with this crop. Care is required in storing soy beans in order that fermentation, to which they are subject, may not occur and injure their vitality. Storing in loosely woven sacks is recommended.

340. Value.—The seeds of soy beans are characterized among legumes in not having any starch in their cotyledons, and in

[1] Kentucky Sta. Bul. No. 98 (1902), p. 20.

having an endosperm. This endosperm contains aleurone (protein) grains and obliterated cells, but contains no starch.[1] The seeds contain a high percentage of protein and an extraordinarily high percentage of fat, being in both respects similar to flax seed and cotton seed. In its high percentage of fat, it is quite unlike other legumes grown for their seed, except the peanut. Where fed to milch cows, soy bean meal has been found by the Massachusetts Station to have a feeding value equal to cotton seed meal, and the Kansas Station found that when it was mixed with either maize meal or kafir corn meal, and fed to pigs, the number of pounds of food required to produce a pound of pork was reduced as compared with either maize meal or kafir corn meal when fed alone. The composition of the whole plant is similar to that of red clover; and, although the soy bean is somewhat less palatable, it is, in the proportion to which it is eaten, similar in feeding value. When placed in the silo, mixed with maize or in alternate layers, it keeps well, is readily eaten and is nutritious.

341. Collateral Reading.—H. Garman: Kentucky Forage Plants, pp. 16-21. Kentucky Station Bul. No. 98, 1902.

Thomas A. Williams and C. F. Langworthy: The Soy Bean as a Forage Crop and as a Food for Man. U. S. Dept. Agr., Farmers' Bul. No. 58, 1899.

[1] Winton: Microscopy of Vegetable Foods, p. 249.

XV

ROOT CROPS

I. BEETS

342. Name.—The term "root crops" is used to apply rather loosely to a class of plants, mostly biennials, in which the food supply is usually stored up the first season in the thickened stem (hypocotyl) and primary root as nourishment for the fruiting stem the second season. With regard to duration, however, there are exceptions, rape being an annual. Even in a single species, such as the beet, individual plants may be found that are annual, and others that are perennial. In some instances, as in the common cabbage, the food supply is stored up in the leaves, while in kohlrabi it is stored in the stem alone. Custom varies as to the use of the term "root crop" to apply to all these plants, but since they all have similar adaptation and uses, and require somewhat similar cultural methods, they are treated together in this chapter under the general term of root crops.

343. Relationships.—Root crops belong to several genera, of which the following are most widely known: (1) *Beta,* including garden beets, sugar beets, and mangel-wurzels; (2) *Brassica,* including turnips, rutabagas, kohlrabi, cabbages, rape, and kale; (3) *Daucus,* including the carrot, and (4) *Pastinaca,* which includes the parsnip. The carrot and the parsnip both belong to the carrot family (*Umbelliferae*), which includes celery, parsley, and caraway, and also a number of disagreeable weeds, among which are the wild forms of carrot and parsnip.

The genus Brassica includes in addition to the above-mentioned plants the mustards, as well as many potherbs, and belongs to the mustard family (*Cruciferae*), which includes the garden radish, horse radish, water cress, and garden cress. The beet belongs to the goosefoot family (*Chenopodiaceae*), which includes spinach and that widely distributed weed, lamb's quarter or pigweed (*Chenopodium album* L.).

344. Types of the Beet.—The beet (*Beta vulgaris* L.) is cultivated in four general forms, in each of which there are many varieties—namely, (1) chard, its leaves used as potherb or for ornamental purposes; (2) garden beet, generally with red-colored flesh, and used for cooking; (3) sugar beet, generally with white-colored flesh, and cultivated for its sugar and for stock feeding; and (4) mangel-wurzels, generally with parti-colored flesh, supposed to be a cross between the former two, and used extensively for stock feeding.

Danish Improved half-sugar mangel-wurzel. An excellent type; pulls up clean, has shallow dimples, good shoulders, single neck and crown, single tap root, and good foliage.

345. Description of the Beet.—The beet, while usually referred to as a "root," is really a modified stem and primary root closely united. The neck, which supports the leaves, and the upper portion or shoulder of the stem constitute the crown which, in the case of sugar beets, is removed preparatory to the manufacture of sugar. The neck should be short and the flesh firm, with no tendency to sponginess or hollowness. The neck contains less sugar and more undesirable compounds, such as nitrates, than the rest of the "root." The neck should be single, since when multiple the extra small shoots grow largely at the expense of the food already stored. The shoulders should not be too flat or concave on top, as this is apt to cause decay.

The primary root appears as a continuation of the stem (hypocotyl), and should terminate in a single small tap root. Secondary prongs or forks increase the cost of harvesting, hold the soil and indicate coarseness. There are two depressions opposite each other running lengthwise, but slightly tangential to the root, known as dimples, from which the lateral roots arise. These should be shallow and as nearly vertical as may be. The lateral roots should be fine and abundant, and their origin confined to the dimples, since when they spring promiscuously from the surface the root is more difficult to dig, and more soil clings to it. The fibrous root system is extensive. In some cases drains four feet below the surface have been blocked by them.

A transverse section of a beet shows a series of (five to seven) concentric rings of firm tissue alternating with rings of softer tissue. The firm or vascular tissue is said to be higher in dry matter and richer in sugar than the intermediate tissue, and the claim is made that the richest roots are those in which these vascular rings are packed closely together. There appears to be no correlation between color of flesh and sugar contents or the feeding value, but roots of white color are preferred for sugar beets on account of other colors interfering with the manufacturing processes.

346. Comparison Between Sugar Beets and Mangel-wurzels.—Sugar beets differ from mangels in color, form, size, depth and vigor of growth, in ease of harvesting, in total yield of fresh roots, in the percentage and the ratio of sugar to dry matter, and in keeping qualities. The skin of the sugar beet is white and the typical form is shown in this paragraph. In mangel-wurzels the color of the skin varies with the variety and may be white, pink, red, orange, golden, purple, or black. The form is equally variable, but the commercial varieties are usually divided into five groups: long, half-long, ovoid, tankard, and globe. Typical sugar beets weigh from 1 to 1.5 pounds, while mangel-wurzels should weigh from 3 to 4 pounds apiece.

Kleinwanzlebener sugar beet

Sugar beets grow almost entirely below the surface of the soil, while with globe-mangel wurzels frequently two-thirds to three-fourths of the root is above ground. With the long shaped varieties one-half to two-thirds of the root may be below the surface. For the reason just stated, mangel-wurzels are more easily lifted than sugar beets, yet more weight must be handled because of the lower percentage of dry matter in the case of the former. It is believed that mangel-wurzels grow rather more vigorously than sugar beets and thus get ahead of the weeds more quickly

The roots of the typical improved sugar beets contain about 20 per cent. of dry matter, about four-fifths of which is sugar. Good varieties of mangel-wurzels contain about 12 per cent. of dry matter, about one-half of which is sugar. The feeding value of beets is not believed to be influenced materially by the ratio of sugar to dry matter, but is dependent primarily upon the content of dry substance. It is believed that loss through external decay and the oxidation of sugar is greater in sugar beets than in mangel-wurzels.

There are several varieties of mangel-wurzels known as half-sugar mangel-wurzels, produced by crossing mangel-wurzels and sugar beets. While some of these varieties have good form and yield well, the composition does not differ materially from ordinary varieties of mangel-wurzels, due doubtless to the fact that external characters have been the basis of selection.


Sutton's long red mangel-wurzel

347. Varieties.—At the Cornell Station, the long red varieties were more productive than the yellow globe and golden tankard varieties, but were somewhat more difficult to harvest. Of the long red varieties, Norbiton Giant, Sutton's Long Red, Garton's Long Red, and Chirk Castle yielded equally well. Among the half-sugar mangel-wurzels, Vilmorin's Half-sugar Rosy, and Half-sugar White were found desirable. Among sugar-beets of value for stock feeding, Danish Improved and Lane's Improved Imperial yielded well. Kleinwanzlebener was expensive to harvest, and retained too large quantities of dirt.

"The two varieties (of sugar beets) which have been most widely grown ir this country are the Vilmorin Improved, and the Kleinwanzlebener. The certainty that the seed has been grown according to the most scientific methods is of greater importance to the beet grower than the variety. The beet has reached such a high state of perfection as to make the least degree of laxity in its treatment exceedingly dangerous to its qualities."[1]

"The essentiais of a good variety are large yields, high sugar content, purity of the juice and keeping quality of the beets. The beet should have an even texture, smooth outline, and symmetrical shape. The typical sugar beet

Golden tankard mangel-wurzel

Carter's Windsor yellow globe mangel-wurzel

should weigh rather more than a pound, contain 14 per cent. of sugar, and 80 per cent. of the total solids in the juice should be cane sugar. There is a tendency for the total yield of the beet to decrease with the increase in the per cent. of sugar. Extremes in either direction should be avoided."[2]

348. Adaptation.—The beet is adapted to a cool climate and a moist soil. Sunshine is especially desirable where high sugar content is desired, hence the comparatively cool sub-humid sections of the western states have been found especially adapted to the growth of sugar beets. Here the soil moisture

[1] U. S. Dept. Agr., Farmers' Bul. No. 52, pp. 8, 9.

[2] Morrow and Hunt: Soils and Crops of the Farm, p. 265.

is obtained chiefly by irrigation or by supplies of underground water which furnish the necessary moisture conditions in the soil. Often under the latter conditions excellent crops of sugar beets are raised, where the rainfall is slight, without any irrigation. Mangel-wurzels are especially adapted to the higher elevations of the North Atlantic states where the shortness of the season and the danger from frost make the growing of maize somewhat uncertain. They can withstand drought better than other root crops. Beets may be grown on almost any type of soil ranging from quite sandy to heavy loams, provided they are fertile and sufficiently deep.

349. Irrigation.—It is generally customary to supply the water by the row method rather than by flooding. The amount of water and the time and number of applications vary greatly with soil and climate. The important consideration is to supply sufficient water to keep up a uniform and continuous growth until the close of the season, but not to start a second growth late in the season, because such growth will reduce the percentage of sugar. Under some conditions, one application made just after the seed is planted may bring good results, while under other conditions of climate or soil, several applications at intervals throughout the growing season are more advisable. At the Utah Station, with a rainfall of seven inches from April to September inclusive, about 20 inches of water at five applications gave larger yields of beets and higher percentage of sugar than less or more water.[1]

350. Rotation.—Beets may occupy the same place in the rotation as that occupied by other inter-tilled crops, such as maize or potatoes; that is, they may follow sod or another inter-tilled crop which has been manured heavily, such as potatoes, cabbage, or maize. Oats is the best grain to succeed them, since the roots cannot be removed in time for fall grain. The land should be

[1] Utah Sta. Bul. No. 80 (1902), p. 177.

fall plowed, care being taken to spread the beet tops uniformly; otherwise an uneven oat crop will result, since the tops are a valuable manure. On account of danger of leaf-spot, at least four years should elapse between two crops of beets on the same soil.

351. Fungous Diseases.—Beets are more or less affected by a number of fungous diseases, the most important of which in America are (1) leaf-spot (*Cercospora beticola* Sacc.), (2) root-rot (*Rhizoctonia betae* Kuhn.), and (3) beet scab (*Oospora scabies* Thaxter). Of these the leaf-spot is the most widely distributed, and probably for that reason does the most damage. This is a mycelium fungus whose fruiting spores occur in small brown spots, turning ash-gray with reddish-purple margins on the surface of the leaves. Spraying early with Bordeaux mixture is recommended, but a rotation of crops is a successful prevention. Late planting reduces the attacks from leaf-spot, but late planting also reduces the yield, and is therefore not to be recommended.[1]

Beet root-rot affects the root while growing in the field, causing the infested part to turn brown, Under conditions favorable to the disease all parts become affected and gradually disappear. This fungus is also believed to be the cause of damping off in young plants of several species, such as cotton and lettuce. It is said not to thrive in an alkaline soil, hence liming is recommended.

Beet scab causes the surface of the beet to become more or less covered with a corky excrescence. This disease is the same as that occurring on potatoes, hence beets should never follow on land that had grown scabby potatoes, or scabby beets.

352. Insects.—The beet being closely related to some of the commonest weeds, there are about 150 species of insects which feed upon it; although only about 40 species can be considered of economic importance. Ordinarily none of these is especially harmful, beets being usually less injured by insect attacks than maize, wheat, cabbage, turnip, or potato. "The principal injurious groups are the leaf-miners, the web-worms, the cutworms, the woolly bears, and several other leaf-eating caterpillars, the wireworms, the white grubs, the flea-beetles, the blister-beetles, the plant bugs, the leaf-hoppers, the plant-lice, and grasshoppers."[2] Spraying with suitable insecticides, and, in other cases, hand-picking are practised, but the usual preventive measures of clean culture and a rotation of crops are the most effective and practical.

353. Preparation of the Soil.—In the preparation of the soil greater care is necessary than for cereals. Usually deep fall plowing is advisable with cross-plowing or deep disk harrowing in the

[1] New York Cornell Sta. Bul. No. 163 (1899).

[2] Illinois Sta. Bul. No. 60 (1900), p. 398.

spring. The seed-bed must be made fine, which usually requires five or six harrowings with disk and spike tooth harrows. Stable manure at the rate of ten loads per acre should be applied previous to plowing in the fall and 200 pounds of acid phosphate and 50 pounds of nitrate of soda may be applied in the spring previous to the last two harrowings. This fertilizer stimulates the young plants. Where beets are grown for purposes of manufacture it is considered expedient to apply the fertilizer to the preceding crop. The great difficulty in the culture of beets is their slow growth while young, allowing weeds to get a start and making it difficult to maintain clean culture. For this reason it is advisable to give the plants just after thinning an application of 50 pounds of nitrate of soda to which 50 pounds of acid phosphate may be added to give it bulk and aid in distribution. Apply, when leaves are dry, close to the plants and follow with cultivator.

354. Seeding.—What is sold in commerce as beet seed is the fruit called the capsule or "bolt," which contains from one to five, usually two to three, seeds. The number of capsules varies from 18,000 to 36,000 per pound. One hundred bolts should produce from 150 to 175 plants. The Michigan Station found no difference in the vitality of sugar beet seed, 1, 2, 3, and 4 years old. A good stand of mangel-wurzel plants is from 25 to 30 thousand per acre, of sugar beets somewhat more. From six to eight pounds of good mangel-wurzel seed are required per acre. Since an even stand is one of the most important considerations in obtaining a maximum yield, it is common in the case of sugar beets to sow 18 to 20 pounds of seed per acre, although obviously this would be a great excess in case all the seeds should germinate.

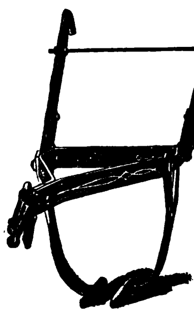
At the Cornell University farm three-fourths inch was found ample depth for seed and one and a half inches too deep. In dry climates, planting one and a half inches deep will probably be found advisable in order to insure sufficient moisture for germination. Where sugar beets are raised on a large scale a drill sowing four rows at a time is commonly used. An ordinary grain drill may be used, however. By closing the proper outlets a 7x11 drill will make rows 21, 28, or 35 inches apart as desired, The Ontario Agricultural College found the best temperature for germination of seed to be 80° F. Yet experiments have clearly demonstrated that early sowing is desirable, generally earlier rather than later than maize.

355. Distance Apart of Rows.—The distance apart of the rows is largely a question of the value of land and the cost of labor. By placing the rows close together larger yields per acre may be obtained; but by placing the rows wider apart larger yields for the amount of labor involved will be secured, since the labor is related to the number and length of rows to be planted, thinned, hoed, and cultivated. It is customary to plant sugar beets in rows of 18 to 20 inches apart when not irrigated, while where irrigated it is advised to plant in double rows 11 inches apart with 27 inches between them for convenience of irrigation. For mangel-wurzels, it is advised to make the rows 28 to 35 inches apart.

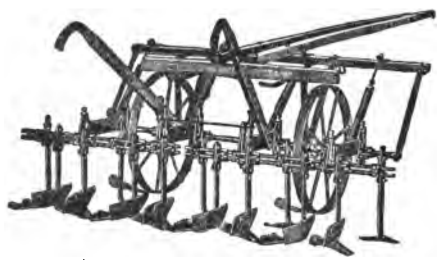
356. Thinning.—As soon as the plants have four leaves, with a hoe five or six inches wide, chop out all the plants in the row except a little bunch every 6 to 10 inches as required, depending on the variety, globes and tankards requiring rather greater width in the row than the long varieties of mangel-wurzels. The bunch of plants must next be thinned to one plant in a place; otherwise small distorted roots will result. It is, also, important that this thinning be done promptly before they become "drawn," since if the plants are checked in any way at this time, the injury will be permanent. This thinning is tedious and expensive, and has led to attempts to crack the fruits into pieces having one seed each. The United States Department of Agriculture is now breeding sugar beets with one seed in a capsule:

thus far the total crops have averaged 26 per cent. of "single-germ" seed, such seed producing beets yielding from 16 to 17 per cent. sugar.[1]

357. Cultivation.—The ground should be harrowed as frequently as necessary after seeding to keep weeds from starting. Shallow cultivation should begin as soon as rows can be seen



A beet puller



A four-row beet cultivator with duck feet and weeding knives

and continued about every ten days until tops meeting in the row prevent further inter-tillage.

358. Harvesting.—The cessation of growth is indicated by the withering of the outer leaves, which usually occurs about the middle of October. Beets will stand some frost, but should not be subjected to severe freezing. The roots should be lifted with as little injury as possible.

In case the sugar beets are to be used for making sugar, the crown is always cut off, but where mangel-wurzels or sugar beets are stored for feeding the tops should be twisted off by hand. The storage should be cool, dry and well ventilated. Experiments indicate that at a temperature of 32° F. beets may be kept for weeks in perfect condition. A root cellar is most convenient, but if necessary they may be pitted, covering with alternate layers of straw and soil, adding layers as the cold

[1] Report of the Secretary of Agriculture (1906), p. 42.

weather increases. Storing should be done as soon as possible, since if allowed to lie long on the ground a loss in sugar content will result from fermentation.

359. Yields.—The possible and probable yields of the different classes of root crops are indicated by the results obtained during two seasons at the Cornell Station. The following table gives dry matter in pounds per acre from sowings made during May:

Kind	Minimum	Average	Maximum
Mangel-wurzel wurzels	824	5,520	10,660
Half-sugar mangel-wurzels	5,960	6,300	10,200
Sugar beets	6,840	8,120	9,000
Rutabagas	2,251	3,920	5,200
Hybrid turnips	2,512	4,060	5,700
Common turnips	800	2,400	3,960
Kohlrabi	3,920	4,460	5,000
Cabbages	3,160	4,280	7,783
Carrots	1,760	3,500	5,320
Parsnips	....	3,200	....

On the same type of soil the same seasons the estimated yield of maize grain was 2,000 pounds and of maize silage 4,000 pounds of dry matter per acre. Ten to fifteen tons of sugar beets and 20 to 30 tons of mangel-wurzels may be considered satisfactory yields. The average yield of sugar per ton of beets in the United States in 1904 was 230 pounds. Under highly improved conditions 16 tons of beets per acre, yielding 250 pounds of commercial sugar per ton or 4,000 pounds of sugar per acre, may be realized.

360. Feeding.—Mangel-wurzels and sugar beets, and indeed root crops in general, have a high feeding value for the amount of dry matter contained. This is due to their succulence and high digestibility. Extensive Danish experiments have shown that the dry matter in mangel-wurzels when fed in large quantities has a feeding value equal pound for pound to a mixture of cereal grains when fed in such a way as to eliminate the influence of succulence. The high character of English mutton is due to root crops, turnips being largely used. The value of root crops to the American farmer is not as a food to take the place of silage and other roughage, but as a partial substitute for cereal grains and other concentrated foods.

It is not considered advisable to feed mangel-wurzels to live stock until after Christmas, as they appear to contain some substances, perhaps nitrates and oxalates, which are laxative, but which characteristic disappears after roots are stored for some time. Before feeding, mangel-wurzels or sugar beets should be pulped, sliced, or cut into finger pieces. This is frequently done twelve hours before required and mixed with low grade hay or straw, thereby adding to the palatability of the latter.

361. Production of Seed.—The beet being a biennial, it is necessary, in order to secure seed, to select individual plants of the desired characters and quality, and store these roots in sand in a pit or cellar. The following spring they are planted in the field and soon throw up their seed stalk and produce seed. A single mangel-wurzel may produce 0.4 pound of seed, hence to secure eight pounds, or the maximum quantity required to sow an acre, 20 roots would be necessary. No method of selecting plants of mangel-wurzels has been practised other than that of external appearance, although selection of roots having a known percentage of dry matter could be done as easily as selection of "mothers" in the case of the sugar beet.

The sugar beet is one of the most striking examples of improvement of composition by selection that has yet been accomplished. The selection of mothers for high content of sugar was first attempted in 1850 by specific gravity of the roots, assuming that roots of high specific gravity would have the highest percentage of sugar. This was followed by selection on the basis of the specific gravity of the juice. In 1867 the polariscope was suggested and has been used ever since. Prior to 1850 the selection of sugar beets was by external characters alone, but there seems to be good evidence to believe that some progress was made in increasing the sugar content. In France, from 1805 to 1815, the sugar extracted was reported to be 3 per cent., in 1829 5 per cent., while in 1904 it was 11.5 per cent. The content of sugar in the juice of sugar beets is reported to have been about 11 per cent. in 1860, about 12 per cent. in 1870-2, and about 14 per cent. in 1885, and 16 to 17 per cent. in 1904, with individual roots as high as 25 per cent.

Having selected a number of roots possessing the desired external characters, a core of the root is extracted by means of a "trier" inserted in a slanting direction from the shoulder. The juice of the core is then analyzed and the roots which show the desired percentage of sugar are retained for producing seed. Immediately after coring, the hole may be filled with charcoal, clay, or cotton batting dipped in formalin to prevent infection of diseases. Different varieties or strains should be planted separately, as the beet probably cross-pollinates rather freely.

362. History.—Manjgraff, of Austria, in 1747 demonstrated that beets contain crystallizable sugar, and Archard, of Berlin, in 1797 announced that sugar could be extracted from them. The first factory was erected in Silesia in 1805; but it was not until 1825 in France, and 1835 in Germany that the manufacture of sugar from beets became an established industry. Fifty years later three million tons of sugar were manufactured annually in Europe. In recent years about one-half the sugar produced in the world comes from beets. The principal beet sugar producing countries are Germany, Austria-Hungary, France, and Russia.

More or less continuous attempts in the production of sugar from beets have been made in various sections of the country since 1863. The total annual production is about 200,000 tons, chiefly in California, Colorado, Michigan, and Utah. In this country the economical production of the beets is the chief difficulty to be overcome. The use of root crops of any kind as food for domestic animals is of comparatively recent origin. Their improvement and use for this purpose appears to have arisen in the Netherlands, Germany, and other low lying regions of northern Europe in the fifteenth and sixteenth centuries. Although the common garden beet had been tried for stock feeding earlier, the improved mangel-wurzel was introduced both into England and America about the middle of the eighteenth century.

Danish Ballhead cabbage

Green top Scotch yellow hybrid-turnip

II. TURNIPS, RUTABAGAS, KOHLRABI AND CABBAGES

363. Types.—A multitude of cultivated forms is supposed to have arisen from *Brassica oleracea* L., a plant native to the coasts of western and southern Europe.[1] These forms

[1] U. S. Dept. Agr., Expt. Sta. Record XI, p. 6.

have been classified into several rather well defined groups. Thus the cabbage tribe (*B. oleracea* L.) includes the ordinary cabbage, cauliflower, broccoli, kohlrabi, kale, and brussel sprouts; while in separate species are placed rape (*B. napus* L.), rutabaga or Swedish turnip (*B. campestris* L.), and common turnip (*B. rapa* L.). Turnips and rutabagas, like beets, consist of a thickened stem and root. In the kohlrabi the stem forms a turnip-like enlargement above ground, while in the cabbage the nourishment is accumulated in the leaves.

364. Description.—Turnips and rutabagas vary in form similar to mangel-wurzels, but in less marked manner. They also vary in color of exposed part of "root," which may be white, yellow, green, bronze, purple or red, and "greystones," the latter term being applied when the upper part is mottled with transverse green and purple streaks.

Maule's Improved Purple-top rutabaga

The flesh is generally either white or yellow. White-fleshed varieties are generally regarded as of lower feeding value, softer and more liable to be injured by the frost than the yellow-fleshed varieties, but they make a more rapid growth. The neck should be small, the crown single and the shoulders convex. The root system of turnips is mainly near the surface.

365. Comparison of Turnips and Rutabagas.—Turnips grow more rapidly, but the rutabagas give higher yields of dry matter and have better keeping qualities. In a rather unsuccessful attempt to combine the keeping qualities of the rutabaga with the more rapid growth of the turnip, numerous crosses have been made to which has been given the name of hybrid turnips. These may have the character of either parent blended in a number of ways.

The turnip and the rutabaga may be distinguished by the following characteristics:

	Turnip	Rutabaga
First foliage leaves	rough	rough
Color of leaves	grass-green	bluish-green or covered with a bluish-white bloom
Later leaves produced during the first year	covered with rough, harsh hairs	smooth
Neck	absent	present
Position of leaves	like a rosette in the center of the upper surface of the "root."	on the neck, which usually shows well defined leaf scars
Period of growth	usually 60 to 90 days	usually 90 to 180 days
Flowers	small, usually yellow	larger, buff yellow to pale orange
"Roots"	usually smooth on the surface and in outline	usually rough on the surface and less perfect in form and outline
Flesh	soft, usually white to yellow, more often white	firmer, white, yellow or orange, more often yellow
Keeping quality of "roots"	generally poor, should be consumed early in the season	generally good, can be kept until spring
Dry matter	5 to 10 per cent.	7 to 12 per cent.
Average weight of "roots"	3 to 12 ounces	16 to 50 ounces
Size of seed	small, 2 to 3 lb. usually sown per acre	larger and darker, 4 to 5 lb. usually sown per acre

366. VARIETIES.—Although the use for forage of headless cabbage or kale is increasing in Great Britain, it is seldom used in America. Among common or head cabbage, Surehead and Autumn King have given satisfactory yields for forage. Holborn Elephant, and Kangaroo rutabagas, Yellow Aberdeen and Pioneer hybrid turnips, and Mammoth and Improved Green Globe turnips are standard varieties for stock feeding.

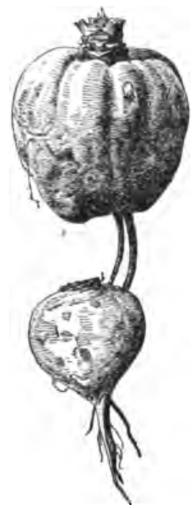
367. Adaptation.—Turnips and rutabagas require a cool, damp, rather dull climate. They will not withstand drought as well as mangel-wurzels, and sunshine is not so important as with the sugar beets. They generally require, especially common turnips, rather sandier soils than beets. Stiff clays are objectionable on account of the difficulty of producing a fine seed-bed, while light sandy and gravelly soils are undesirable because of the lack of surface moisture.

368. Cultural Methods.—The preparation of the soil and the cultivation, harvesting, and storing of the crops are similar to mangel-wurzels. If anything, a finer seed-bed is required, but the more rapid growth and the single seed make cultivation and thinning easier. These crops should never be grown continuously upon the same ground and should never succeed one another. The famous Norfolk four-course rotation which helped to revolutionize the agriculture of England in the seventeenth century consisted of turnips; grain, usually barley; "seeds," a mixture of clover and grasses; grain, usually wheat, each one year. In the United States, rutabagas may occupy the same place in the rotation as suggested for mangel-wurzels.

369. Seeding.—Common turnip seed may vary from 200,000 to 260,000; rutabagas from 160,000 to 190,000; kohlrabi from 115,000 to 130,000; and cabbage from 80,000 to 140,000 seeds per pound. The germinating power should not be less than 90 per cent., although it frequently is in commercial seed.

The number of plants per acre should be for cabbage 7,000 to 10,000; for rutabagas and kohlrabi 20,000 to 30,000; for common turnips somewhat more. Four pounds of rutabaga and hybrid turnip seed and three pounds of common turnip seed are usually sown when in rows 27 to 36 inches apart. Seeds should be sown at a depth of one-half to three-fourths inch. Small hand garden drills are available for this purpose. Turnips, kohlrabi, and rutabagas must be thinned as directed for beets.

Cabbage may first be planted in flats in the greenhouse or cold-frame and transplanted to the field by hand or by means of the cabbage planter; or a few seeds may be dropped in the field every 18 to 24 inches apart in the rows and the plants thinned—when three or four leaves have developed—to one in a place. No material difference in yield appears to result from these two methods, so that the method employed will depend on the convenience and expense. The distance apart in the row will depend on the purpose for which the cabbages are grown. Where they are sold for ordinary culinary purposes a larger number of small cabbages are desired, while for forage purposes or for sauerkraut a smaller number of large cabbages is best. Early seeding is essential to high yields, earlier even than for mangel-wurzels, although common turnips may be sown as a catch crop as late as July.



Carter's Purple-top Mammoth turnip, showing the variation in size of early sown above and late sown below.

370. Enemies.—All plants of the mustard family are subject to the attacks of the club-root or finger-and-toe disease (*Plasmodiophora brassicae* Wor.) which causes the root to take on abnormal shapes and may seriously reduce the yield; and by black rot (*Pseudomonas campestris* (Pammel) Erw. Smith). Both are best combated by a rotation of crops. Lining is also considered beneficial.

Black rot is a bacterial disease. The disease usually makes its appearance on the outer leaves of the cabbage, near the margin, entering by way of the large marginal water pores, but infection may also occur through the roots or at the base of the leaf close to the stem. The disease spreads through the entire plant by means of the veins. The leaves, being deprived of water, become dry, turn yellow, and perish. A diseased leaf shows the blackened veins, or a cross-section of a diseased leaf or stem discloses black spots instead of the faint yellowish spots of a healthy plant. So far as known, the disease spreads by contact, or by inoculation of the leaves by leaf-eating insects, or of the soil with germs which are believed to pass the winter in the soil, or which may be incorporated in manure from stock fed on diseased plants. It is also believed to be propagated by means of inoculated cabbage seed which may occur on the market. In this case the precaution is recommended to disinfect seed by soaking for 15 minutes in a 0.001 corrosive sublimate solution, or in formalin, one pound to 30 gallons, and dry before sowing. The disease not being thoroughly understood, no satisfactory method of controlling the disease in the field has been found.[1]

The larva of the wavy striped flea beetle (*Phyllotreta vittata* Fab.) frequently attacks the roots of the plants, destroying many of them. The most practical preventive is early seeding. Sowing thickly and thinning, if necessary, may bring good results.

The green cabbage worm (*Pontia rapae* Sch.) is a serious pest. It is important to kill the first spring brood, which becomes mature in two or three weeks. If practicable, hand picking early in the morning for the first two or three weeks of the seedling will prove beneficial. Spraying the young plants with an arsenious solution and the old plants with pyrethrum or hellebore is recommended for this pest, and for the cabbage looper (*Autographa brassicae* Riley). The harlequin cabbage bug (*Murgantia histrionica* Hahn.) is a serious pest in the southern states. Once it gets a hold it is liable to remain. While mustard and radish plants are recommended to be sown for traps, when the bugs may be destroyed by spraying with kerosene, this practise more frequently increases the numbers and the only effective means of combating so far found is hand picking. The cabbage maggot (*Pegomya brassicae* Bouché), and the cabbage plant louse (*Aphis brassicae* L.) sometimes do considerable injury. Spraying with whale oil soap solution has been found an effective remedy for the latter.

371. Yields.—The yield of dry matter or fresh substance is not so large in rutabagas as in mangels, and in common turnips it is even less. (359) Five to fifteen tons of common turnips and 15 to 20 tons of rutabagas and kohlrabi may be considered fair yields. Under favorable conditions over 40 tons of cabbage of stock feeding purposes may be obtained, 20 to 30 tons being frequent. Cabbages usually contain 6 to 7, common turnips 7 to 9, rutabagas 8 to 10, and kohlrabi 9 to 11 per cent. of dry matter.

372. Value.—The common turnip is valued as a catch crop, and may be used for feeding on the ground early in the season. For the farmer who wishes to raise "roots" to supplement the grain ration in Canada and the cooler and moister portions of the United States, where maize is a rather uncertain crop, cabbage may be grown for feeding cattle and sheep while on

[1] New York State Sta. Bul. No. 232 (1903); 251 (1904).

pasture during September and October. It is not advisable to store cabbage for feeding purposes. Rutabagas may be grown and stored for feeding during November and December, while mangel-wurzels may be grown for later feeding. Rutabagas are desirable to feed throughout the winter to brood sows and other pigs. Carrots are especially desirable for horses. Lazenby reports that, when fed to horses, one bushel of oats and one bushel of carrots together were equal in feeding value to two bushels of oats.

It is claimed that as compared with rutabagas, kohlrabi withstands drought better, can be grown on heavier soils, and in a climate too warm for the best development of rutabagas; it withstands frost better and is not so subject to club root. Little is known of its feeding value. The seed, on account of the small demand, is high priced and apt to be of poor germinating power.


Thorburn's large white Vienna kohlrabi

373. Production.—The cultivation of turnips as food for stock was introduced into England from the continent about 1650 and caused great changes and improvements in British agriculture, including live stock husbandry. They have never been extensively grown in the United States. In Canada turnips are still the leading root crop grown for stock feeding.

III. RAPE

374. Description and Varieties.—Rape (*Brassica napus* L.) has much the same habit of growth as kale or headless cabbage, to which it is closely related. Under cultivation it grows from 1.5 to 4 feet high, has large, variously divided smooth leaves borne on stems; flowers nearly 0.5 inch in diameter, yellow; seeds resembling those of cabbage and turnip but larger.

There are two types of rape: (1) annual or summer rape, sometimes known as bird seed rape, and (2) biennial or so-called winter rape. Summer rape is grown extensively in Europe for seed, which yields 33 per cent. of expressed oil used for lubricating and lighting, and rape seed cake highly valued for stock feeding and fertilizer. It is winter rape that is used for forage in America. The most widely cultivated variety of this type is the Dwarf Essex. Seed of winter rape can be grown only where the plants will survive the winter. This occurs on the Pacific coast, where a yield of 1,000 pounds of seed per acre is said not to be unusual.[1] Ordinarily, however, seed is secured from Europe. The necessity of annually purchasing seed tends to prevent its use, although one of the strong points in favor of the growing of rape is the cheapness and small quantity of seed required: 3 to 5 pounds per acre are sufficient.

The rape plant
(After Hitchcock)

375. Adaptation and Cultivation.—Rape has a climatic and soil adaptation similar to cabbage, turnips, and rutabagas,

[1] U. S. Dept. Agr., Farmers' Bul. No. 164, p. 10.

although it is less easily injured by fall frosts. It is reputed to be able to get its food supply from relatively insoluble forms of commercial and other fertilizers, hence to grow well on new lands or those containing large quantities of organic matter, and on land fertilized with coarse manure or rock phosphate. (C. A. 406)

It germinates and grows rather rapidly, hence weeds usually cause little trouble. In fact, it is recommended as a weed destroyer.

"An excellent treatment for a foul field is to plow thoroughly in late summer or early autumn and seed to rye or some other forage crop to be pastured off during the fall, winter, or early spring. When the crop has been pastured sufficiently, and before the weeds have produced seed, plow again, plant rape in drills and give thorough cultivation. There are few weeds that will survive such treatment, and the land will have given profitable returns in forage in the meantime."[1]

Rape may be sown in drills preferably 28 to 35 inches apart, and given inter-cultural tillage, or may be sown broadcast or drilled with grain drill as for cereals at any time from May to August inclusive in Canada and the northern United States. In general, drilling will be best for early seeding, while broadcasting will be sufficient for later seeding. It is ready to use in eight to ten weeks after seeding. In the southern states it may be fall sown for winter pasture.

It may be sown after early maturing crops are removed, in maize at the last cultivation, or in the spring with oats. (C. A. 406) Since it is usually grown for summer and fall pasture, the location of the field will generally be more important than the place of the crop in the rotation.

376. Value.—"Among all forage crops possible and profitable of cultivation in Canada none seems worthier of a more extensive use than rape. It is simple of culture; it makes a strong, rapid growth; it adapts itself readily to different soils and to various climatic conditions; it responds vigorously to fertilizer

[1] U. S. Dept. Agr., Farmers' Bul. 164, p. 13.

and to good cultivation; and, most important of all its good qualities, it is palatable, wholesome and nutritious green food for all kinds of live stock on the average Canadian farm."[1]

It is most highly prized for growing pigs and fattening sheep. While successfully used for soiling, it is used principally for pasturing, never being cured for dry forage. In composition and feeding value it is similar to clover and alfalfa pasture, and is less likely to occupy an important place where these plants produce abundant summer and fall pasturage. Rape is apt to cause bloating in cattle and sheep under conditions similar to those mentioned for clover and alfalfa. (167)

IV. CARROT

Lobberich's Agricultural carrot. Plant in bloom on right is annual, rough and covered with knobs. Plant on left is biennial and better in quality

377. Carrot. — The carrot (*Daucus carota* L.) is characterized by its finely divided leaves and by the umbel which bears the seeds being concave and dense, resembling a bird's nest. A section of the "root" shows an outer layer and an inner cone, usually of different colors and shades. The outer layer is considered to have the higher feeding value. The varieties of the carrot may be readily classified according to the color both of the skin and of the flesh, as red, orange, yellow, or white. Some

[1] Central Experiment Farm, Ottawa, Canada, Bul. No. 42 (1903), p. 3.

varieties taper from the crown to the tap root, while others are cylindrical for at least two-thirds their length and then taper to the tap root. In other varieties the carrot ends abruptly and the tap root arises from a comparatively flat surface. The so-called stump-root varieties are considered desirable for shallow soils.

378. Adaptation.—Carrots have a wider climatic adaptation than mangel-wurzels and rutabagas, but prefer a deeper sandy loam. They may be successfully grown on less fertile soils than the former. Stable manure, unless well rotted, is best applied to the previous crop, because of the necessity for a fine seed-bed and as few weeds as may be. Carrots are not much affected by fungous diseases or insect enemies.

379. Seeding.—The commercial seed is a fruit. Since the spines of the fruit cause the seeds to cling together, they are sometimes removed, thus enabling the seed drill to place the seed more uniformly. There are 410,000 to 460,000 seeds to the pound. The percentage of germination is apt to be low, but should not be below 80 per cent. It is desirable to have plants about three inches apart in rows about 30 inches wide, or from 50,000 to 60,000 plants per acre. It is customary to sow about six pounds of seed per acre, but if seed is good a less quantity should be sufficient.

380. Cultural Methods.—The cultural methods are similar to those for mangel-wurzels and rutabagas. The germination and early growth are even slower than in the case of sugar beets. Keeping the land clean and thinning the carrots are the chief difficulties in raising them.

381. Yield.—With a good stand, yields of 10 to 20 tons per acre may be obtained, and yields of 25 to 30 tons are occasionally reported. (359) The percentage of dry matter (11 to 13) is higher than for other forms of roots, except sugar beets. The tops of carrots appear to have a higher feeding value than the leaves of mangel-wurzels or rutabagas. Yields of four tons of tops per acre are reported.

V. MINOR ROOT CROPS

382. PARSNIPS (*Pastinaca sativa* L.) require similar conditions, for their best development, to carrots. The cultural methods of carrots and parsnips are substantially alike, and similar difficulties in raising them are encountered. Parsnips are well liked and sometimes recommended for dairy cattle. The low yield, however, appears to preclude their general use. Unlike most other roots, they are improved rather than injured by freezing, and may be left in the ground until spring.

383. CASSAVA (*Manihot utilissima* Pohl.) AND SWEET CASSAVA (*M. palmata* var. *aipi* Mill. Arg.).—"A native of the tropics, but recently introduced in Louisiana and Florida. On fertile soil it is said to yield as much as 10 tons of roots per acre, and the roots are worth fully as much as potatoes for feeding. The plant is propagated by planting short cuttings of the stems, and requires only ordinary cultivation. As the roots decay quickly after being taken out of the ground, they should be dug only as wanted for use.

Hollow crown parsnip

384. CHINESE YAM (*Dioscorea divaricata* Blanco; *D. batatas* Decne).—"The roots are quite large, club-shaped, often reaching three feet in length with a diameter of three inches at the lower end. They are starchy and mucilaginous, and make a food fully as rich as sweet potatoes, but their peculiar shape makes them hard to dig. The plant is propagated by means of small tubers, which are produced in immense numbers in the axils of the leaves, and on a rich loamy soil the yield of these tubers is often 50 or more bushels per acre. These tubers remain on the surface of the ground uninjured during ordinary winters, and so are a valuable winter food for hogs.

385. CHUFA (*Cyperus esculentus* L.).—"A perennial sedge that produces a large yield of small tubers which are valuable food for hogs. It grows

best on a well fertilized, sandy soil where it makes a yield of from 75 to 100 bushels per acre. The tubers are planted in early spring, 12 to 15 inches apart in rows 3 to 4 feet apart, and the only cultivation needed is to keep down grass and weeds. The tubers mature in October and November, and are easily rooted out by the hogs. This plant is of little value on heavy soils."[1]

386. Jerusalem Artichoke (*Helianthus tuberosus* L.) is a coarse, strong-growing species of sunflower, producing tubers which resemble potatoes in size and shape. The plant is almost certainly of American origin. It was cultivated both in Europe and America at least two hundred years ago. The plant is hardy, easily cultivated, and produces large yields of tubers well liked by hogs.

The tubers may be planted in the same way as potatoes, in rows three to four feet apart as early in the spring as convenient. The land should be kept cultivated until the stalks have made sufficient growth to shade the ground. The food value per pound of tubers is low, and often it is not profitable to dig and store the tubers. The stalks may be cut with a mowing-machine, and the tubers plowed to the surface, when pigs may be turned in the field to eat them. Hogs will also dig them from the ground.

The tubers are not injured by frost. Usually enough of the tubers are left in the ground to continue an abundant growth the next season. The surface may be leveled in the spring and, after the crop has started to grow, by use of plow or cultivator the plants, except those in rows, may be killed. In some cases difficulty has been experienced in getting rid of the crop, but ordinarily this can be done with little trouble. There are several varieties, differing in size, color, and shape of the tubers, but little attention has been paid to selection or improvement of the plant.

Practicums

387. Study of Characters of "Roots."—Supply students with types and varieties as indicated below, and have them designate the characters which are applicable.

1. *Beets*—

Type: Mangel-wurzel; half-sugar; sugar.

Shape: Long; intermediate long; tankard; globe: smooth; forked; rough: uniform in width; tapering.

Dimples: Present; absent: well supplied with fine roots; not well supplied with fine roots.

Color of skin: Red; orange; yellow; white.

Color of flesh: White; white-red; yellow.

2. *Carrots*—

Type: Taper-pointed; stump-rooted.

Shape: Long; half-long; short: cylindrical; not cylindrical.

Core: Large; medium; small; absent: reddish; yellowish; whitish.

Color of skin: Orange; yellow; red; white.

[1] U. S. Dept. Agr., Farmers' Bul. No. 102, p. 46.

3. *Turnips*—

Type: Common; hybrid; cowhorn; rutabaga.

Shape: Flat; round; globular; tankard; long: smooth; forked; rough: uniform in width; tapering.

Top: Flat; round; purple; bronze; green-yellow; white.

Color of skin: White; yellowish. Color of flesh: White; yellowish.

4. *General*—

Neck: Long; medium; short; absent.

Shoulders: Square; round: prominent; slight.

Crown: Single; multiple.

Length: Total..........; above ground..........; below ground.........; Percentage of root below surface..........

Greatest circumference..........

Distance plants may be asunder in rows..........

Disease: Present; absent. Give name.

Average weight of four specimens..........

388. Increase of Dry Matter in Mangel-wurzels by Selection.—Require students to select three mothers from a pile of not less than 25 roots, giving attention to the following external characters:

Size, not less than two pounds; crown, single; neck, small; shoulders, convex; dimples, shallow and well supplied with fine roots, which readily break off when root is harvested; tap root, single.

Core each with a trier. Extract a core with a cheese trier from each root in a slanting direction from the shoulder. Place each core in a small porcelain dish of known weight and weigh at once. Dry in a hot water oven until constant weight is obtained. Determine weight of residue, and calculate percentage of dry matter. Plug the hole in the root with cotton batting which has been dipped in a solution of formalin. If up to a given standard—say 12 per cent. dry matter—bury roots in sand in a dry, cool, well-ventilated cellar.

389. Determination of Specific Gravity of Root and Juice.—Require students to sample a number of roots of which the following may be suggested:

Root	Weight of sample in air	Weight of sample and wire in water	Weight of wire	Weight of sample in water	Sp. gr. of root	Sp. gr. of juice
Mangel . . .	......	......	......	......	......	......
Mangel . . .	......	......	......	......	......	......
Mangel . . .	......	......	......	......	......	......
Sugar beet . .	......	......	......	......	......	......
Sugar beet . .	......	......	......	......	......	......
Cowhorn turnip .	......	......	......	......	......	......
Common turnip .	......	......	......	......	......	......
Rutabaga . .	......	......	......	......	......	......
Carrot . . .	......	......	......	......	......	......

Method of Determination.—With the cheese trier take out a piece from about the middle of the "mother root." Weigh it to milligrams and record. Fill beaker with water, hang the sample by the wire to the beam of the balance in the water: make sure it does not touch the side of the beaker. Weigh and record. Weigh the wire and record, and deduct from the weight of the root and wire. The result is the weight of the root in water, and is to be deducted from the weight of the sample in air to furnish a divisor. The weight of the sample in air is the dividend, and the quotient obtained is the specific gravity. The specific gravity of juice is obtained by extracting the juice and reading by means of the hydrometer.

390. Collateral Reading.—Thomas Shaw: Forage Crops other than Grasses. New York: Orange Judd Co., 1900.

C. L. Allen: Cabbages, Cauliflower and Allied Vegetables. New York: Orange Judd Co., 1902.

L. S. Ware: Beet Sugar Manufacture and Refining, Vol. I, pp. 16-35. New York: John Wiley & Sons, 1905.

Guilford L. Spencer: A Handbook for Chemists of Beet-sugar Houses and Seed-culture Farms, pp. 190-6. New York: John Wiley & Sons, 1904.

Charles F. Saylor: Progress of the Beet-sugar Industry in the United States in 1901. U. S. Dept. Agr. Report No. 72, pp. 61-74

Geo. B. Harrison: The Beet-sugar Industry in Kansas. Kansas State Bd. Agr. Report (Quarter ending September), 1906.

H. W. Wiley: The Sugar Beet. U. S. Dept. Agr., Farmers' Bul. No. 52, 1899.

C. O. Townsend: Relation of Sugar Beets to General Farming. In U. S. Dept. Agr. Yearbook 1903, pp. 399-410.

Thomas A. Williams: Rape as a Forage Plant. U. S. Dept. Agr., Div. Agros. Circ. No. 12, 1899.

A. S. Hitchcock: Rape as a Forage Crop. U. S. Dept. Agr., Farmers' Bul. No 164, 1903.

J. H. Grisdale: The Rape Plant. Dept. Agr., Central Expt. Farm, Ottawa, Can., Bul. No. 42, 1903.

Samuel Fraser: Cabbages for Stock-feeding. New York Cornell Sta. Bul. No. 242, 1906.

Samuel Fraser, John W. Gilmore, and Charles F. Clark: Roots for Stock-feeding. New York Cornell Sta. Bul. No. 243, 1907.

XVI

FIBER CROPS

CLASSIFICATION AND PRODUCTION

391. Materials for Fibers.—There are two sources of fibers: animal fibers, of which there are two kinds, wool and silk, and vegetable fibers.

The cells of plants are divided into two kinds: (1) cells with soft walls, having but little structural or tensile strength, easily subject to decay and usually more or less globular in shape, known under the general term of parenchyma tissue. Young plants and the young parts of plants consist largely of these soft cells of parenchyma tissue. It is for this reason that the young parts of plants collapse or wilt when water is withdrawn from the cells. (2) Cells with thickened and tough walls. Such cells are known as wood cells and constitute the bulk of what is known as wood. The wood cells are of two kinds: (a) ducts or vessels consisting of cells placed end to end with the partitions removed, thus constituting continuous passage through the plant and (b) wood cells or fibers, which are elongated more or less spindle-shaped cells with pointed ends. These cells overlap each other, and usually occur in a continuous bundle of cells, known as fibrovascular bundles. In the softer parts of all higher plants and throughout the stems and leaves of endogenous or monocotyledonous plants, these fibrovascular bundles occur at more or less irregular intervals, while in exogenous or dicotyledonous plants, the hard parts consist almost exclusively of wood ducts and fibrovascular bundles.

While all the higher plants, therefore, contain woody fibers or cells, and in that sense all are fiber plants, only those fibers are useful for textile purposes which have the requisite strength, length, fineness, flexibility, and elasticity. In addition to the fibrovascular bundles which occur in the stems, leaves and bark of plants, there are certain simple cells which grow on the surface of plants, especially on the seeds, which are adapted to textile uses, and which, to distinguish them from fibrovascular bundles, are called surface fibers.

392. Classification According to Use.—In the widest sense, there is no limit to the character of the fiber or to the plants to be used for fiber. The following classification has been proposed, as covering all the possible economic uses of the vegetable fibers:[1]

A. Spinning fibers—
  1. Fabric fibers.
  2. Netting fibers.
  3. Cordage fibers.

B. Tie materials—

C. Natural textures—
  1. Tree basts with tough interlacing fibers.
  2. The ribbon layer basts.
  3. Interlacing structural fibers or sheaths.

D. Brush fibers—
  1. Brushes manufactured from prepared fiber.
  2. Brooms or whisks.
  3. Very coarse brushes or brooms.

E. Plaiting and rough weaving fibers—
  1. Used in articles of attire, as hats, sandals, etc.
  2. Mats and mattings, also thatch material.
  3. Basketry.
  4. Miscellaneous manufactures, as willow ware.

F. Various forms of filling—
  1. Stuffing or upholstery.
  2. Calking.
  3. Stiffening, as in the manufacture of "staff."
  4. Packing.

[1] U. S. Dept. Agr., Fiber Investigations, Rpt. 9 (1897): A descriptive catalogue of useful plants of the world, including the structural and economic classification of plants, p. 31.

G. Paper material—
1. Textile papers.
2. Bast papers.
3. Palm papers.
4. Bamboo and grass papers.
5. Wood pulp and cellulose.

393. Classification According to Source.—This book will deal only with those plants which produce spinning fibers, although they may be used for other purposes. Spinning or textile fibers are used either for producing fabrics or for making cordage ranging from the finest threads to the largest ropes. A somewhat immediate use may be recognized in various forms of netting ranging from laces to hammocks and fish nets.

Spinning or textile fibers may be classified according to their source into bast fibers, structural fibers, and surface fibers, or into soft fibers, hard or leaf fibers, and cotton fiber. Bast fibers come from the inner bark of certain exogenous plants. They are especially valuable because of their fineness, strength, and flexibility for the production of high grade fabrics and their use is made economically possible when the tissue of the stems and bark is easily disintegrated and removed.

Structural fibers are fibrovascular bundles occurring in the leaves or leaf stems of certain endogenous plants. In some cases the fibrovascular bundles occur in isolated groups throughout the tissue, as in sisal hemp, while in other cases they occur more thickly grouped near the surface, as in the case of abacá or manila hemp. These fibers are frequently of great length, but usually lack the flexibility of bast fibers.

394. Classification According to Spinning Units.—Looked upon as spinning units, fibers may be classified into two kinds: (1) fibers consisting of single cells, as cotton, or at most two or more simple cells end to end; (2) fibers made up of bundles of spindle-shaped cells overlapping each other and fastened together more or less firmly by various kinds of cementing material. In the case of cotton, therefore, the length of the fiber and of the cell is the same, since the fiber consists of a single cell; but in bast and structural fibers the length of the fiber is many times the length of the single cells, since each fiber is composed of many cells. Thus according to Wiesner the raw fiber of flax varies from 8 to 55 inches in length, while the length of the individual cells composing the fibers varies from 0.08 to 0.16 inch.[1]

The readiness with which the material that helps to hold the individual cells together may be removed, as, for example, when washed with soap, affects the wear when made into cloth, and methods have been devised for determining the readiness with which these and other substances may be removed as a partial basis for judging the value of fibers. (400)

The following outline classifies the most important fiber plants of America into the three groups mentioned:

Spinning or textile fibers	Fibrovascular structure	Bast or soft fibers	Flax Hemp
		Structural or hard fibers	Manila hemp Sisal hemp Istle or Tampico fiber
	Simple cellular structure	Surface fibers	Cotton

395. Identification of Fibers.—The simplest test for distinguishing animal from vegetable fibers is burning. Vegetable fibers when thoroughly burned leave a white powdery ash, while animal fibers leave a crisp coal. On account of the relatively large percentage of nitrogen in animal fibers the ammonia evolved may be recognized by the odor.

Animal fibers which consist principally of nitrogenous com-

[1] Matthews: Textile Fibres, p. 99.

pounds are soluble in certain acids and alkalis, while vegetable fibers, composed largely of carbohydrates under the general term of cellulose, are insoluble in nearly all of the usual solvents, although readily dissolved in a solution of copper oxide in ammonia. Silk is more soluble in certain solutions than wool, by which means they may be identified. While vegetable fibers are not soluble in ordinary acids and alkalis, they may be disintegrated or greatly modified by solutions which will not injure wool. Many processes of freeing wool from cotton and other vegetable substances, such as seeds and burs, are based upon the fact that weak acids and alkalis will disintegrate the cellulose, after which the fragments may be shaken out. Many manufacturing processes, such as giving a silky luster to cotton, are based upon the action of chemicals on the fibers.

Woolen fibers can be recognized under the microscope by the scales which point toward the outer end. Many of them appear not unlike a series of baskets placed one within the other. Silk and usually vegetable fibers have a smooth surface. The cotton fiber is very much twisted. Different vegetable fibers vary in color when treated with certain reagents. The cells also vary in length, thickness, and shape, a knowledge of which may help in identifying fibers. (399)

396. Number of Fiber Plants.—While there are hundreds of plants that might be used for fiber plants, and while there are 30 to 40 plants which enter into the world's supply, and 20 to 30 which are used commercially in America, the most important of these from the standpoint of manufacture are cotton, flax, jute, hemp, manila hemp, ramie, sisal hemp, and istle or Tampico fiber.

397. Production.—Of cotton, America raises a great excess for export, less than half the hemp required for local consumption and practically none of the flax fiber, although producing nearly one-half of the world's supply of flax seed, about equally divided between North and South America. Manila hemp comes principally from the Philippines, and sisal hemp and istle from Mexico, while jute comes from India and China. All other vegetable fiber plants are secondary in importance to cotton, which is also gaining in importance compared with wool or silk.

Practicums

398. Identification of Fibers.—Give each student one gram each of silk, wool, cotton, and two grams of a piece of cloth composed of silk, wool, and cotton, all having been soaked in ether or benzine to remove possible material which may prevent action of reagents.

Place the samples of silk, wool, and cotton in small beakers and add 10 per cent. solution of caustic soda (NaOH). The cotton remains insoluble; the silk and wool are dissolved. To the alkali solution add lead acetate. In the case of the silk the solution does not blacken, but in the case of the wool it does on account of the formation of lead sulphid. Pick apart the piece of cloth so that the reagents may act readily, place in beaker and add a solution of basic zinc chlorid, made by taking a solution of zinc chlorid of 1.70 specific gravity, and dissolving it in an excess of zinc oxid. Heat for five minutes and filter. The silk having been dissolved the loss is the silk originally present. Heat the residue in 10 per cent. solution of caustic soda, and filter. The loss represents the wool originally present; the residue is cotton.[1]

To determine the amounts quantitatively it will be necessary to determine the percentage of moisture present, and also the finishing materials and coloring matters which may be present. These may be removed by boiling in a 1 per cent. solution of hydrochloric acid, then in a 1/20 per cent. solution of sodium carbonate, and finally in water.

399. Microscopic Examination of Fibers.—Give each student a small sample of wool, silk, cotton, flax, and manila hemp, and also a piece of cloth composed of wool, silk, and cotton. Prepared slides showing cross sections and longitudinal view of fibers are also desirable. A compound microscope with one-sixth inch objective is required, and a camera lucida is desirable, but not necessary. Answers should, as far as possible, be illustrated with sketches.

Surface of fiber: smooth; scaly; sketch.
Frequency of twist or scales: give number per definite length or area......
Luster by reflected light: high; medium; dull.
Transmitted light: transparent; translucent; opaque.
Ends of fiber: forked; pointed: sharp; blunt.
Length of fiber:..........; breadth..........

[1] For further details, see U. S. Dept. Agr., Fiber Investigations Rpt. No. 9 (1897), p. 354; also Matthews: Textile Fibres, p. 247.

Cross section: shape; sketch.

Identify kinds of fiber in woven cloth.

400. VALUE OF FIBERS AS DETERMINED BY ACTION OF REAGENTS.—For this purpose, use samples of raw cotton, flax, and jute fibers.

1. Resistance to bleaching: Boil a weighed portion, say two grams, in a 1 per cent. solution of caustic soda for five minutes. Determine loss in weight.

2. Resistance to laundering: Boil a weighed portion in a 1 per cent. solution of caustic soda for one hour. Determine loss in weight.

3. Percentage of cellulose: Boil a weighed portion in a 1 per cent. solution of caustic soda for five minutes, wash and expose to an atmosphere of chlorine gas for one hour. Wash and raise slowly to boiling point in basic sodium sulphite, and boil for three minutes. Wash and boil in 20 per cent. solution of acetic acid. Washed and dried residue is weight of cellulose.

4. To determine minimum loss in weight in clear raw fiber for commercial use: Boil weighed portion of raw fiber in 20 per cent. solution of acetic acid for one minute. Wash with alcohol and water, and determine weight of dried residue.

5. To note changes due to strong alkali and acid: Expose a small sample to a 33 per cent. cold solution of caustic potash and another sample to equal volumes of cold concentrated nitric and sulphuric acids for one hour. Note results.[1]

401. COLLATERAL READING.—E. A. Posselt: The Structure of Fibers, Yarns, and Fabrics. 2 vols., pp. 13-15, 73-5, 189. Philadelphia: The Author, 2152 North Twenty-first Street, 1891.

Julius Zipser (translated by Charles Salter): Textile Raw Materials and their Conversion into Yarns, pp. 7-56. London: Scott, Greenwood & Co., 1901.

C. R. Dodge: The Structural and Economic Classification of Fibers. In U. S. Dept. Agr., Fiber Investigations Report No. 9: A Descriptive Catalogue of the World, pp. 9-33.

J. Merritt Matthews: The Textile Fibres, pp. 97-109. New York: John Wiley & Sons, 1904.

[1] For further details, see U. S. Dept. Agr., Fiber Investigations Rpt. No. 9 (1897), p. 19.

XVII

FIBER CROPS

COTTON

Structure and Composition

402. Relationships.—Cotton fiber is derived from several species of the genus *Gossypium* belonging to the mallow family (*Malvaceae*). Okra (*Hibiscus esculentus* L.) and hollyhock (*Althaea rosea* Cav.) belong to the same family. The species of the genus *Gossypium* may be herbaceous, shrubby, or tree-like, and are all probably under natural conditions perennial. A characteristic of this genus is the black spots or glands on nearly all parts of the plant. The principally cultivated species, upland or short staple cotton (*G. hirsutum* L.), is herbaceous and under cultivation an annual. The discussion which follows relates to this species when not otherwise stated.

403. Roots.—While normally the cotton plant has a strong, branching tap root penetrating deeply, the root system is subject to much modification, due to the nature of the soil and the sub-soil. In some instances the tap root may be absent. At the South Carolina Station well-developed tap roots were traced in sandy soil and sub-soil to a depth of two to three feet without coming to their end. On heavy clay loam only one plant out of twenty had a well-developed tap root over nine inches long. In either kind of soil the lateral roots began about three inches below the surface of the soil and spread out in all directions, most of them being within nine inches of the surface, although some of them bent down abruptly, penetrating as far as three feet when they were broken off.[1] The Alabama Station reports that most of the lateral roots originate at 1.5 to 2 inches below the surface of the ground, and that their direction is such that deep cultivation would break a large proportion of the feeding roots.[2] The bark of cotton roots is reputed to have medicinal properties similar to that of ergot. (C. A. 488)

American upland cotton. A short-jointed, long fruit limb plant. An extremely early productive plant on which fruiting began near the ground at the first joints on the main stem. There are only four primary limbs and the two older are well fruited. Age 120 days, height 5 feet, bolls 70, 2 open, in lower half circle 54 grown bolls. Leaves removed.

(From photo by Bennett)

404. Vegetative Portion.—The cotton plant has a stout, erect stem one-fourth to one inch in diameter and one to five feet in height, usually two to three feet, with widely spreading branches. The leaves are alternate and the branches arise in the axils of the leaves. The stem is circular and distinctly tapering. The stems and branches are covered with a strong greenish or reddish-brown bark, containing a large per cent. of bast fibers. The pith is large; the wood is soft, white and easily decays.

The distance between nodes varies with climate, soil and cultivation. According to the Texas Station, the tendency of any variety when planted late is to produce longer joints, and to grow taller than when planted early; although to some extent this characteristic is hereditary in different individuals of the same variety.[3] A variety may therefore be modified, in this

[1] South Carolina Sta. Bul. No. 7 (1892).

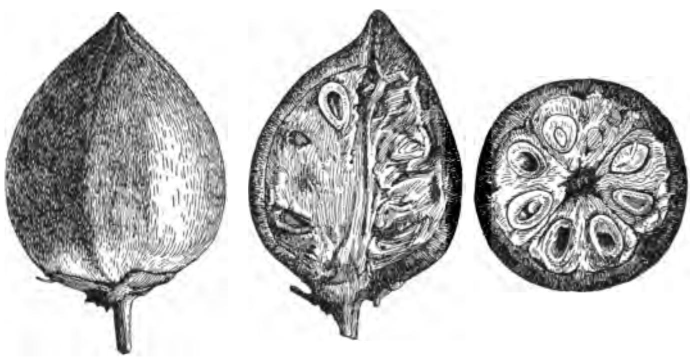
[2] Alabama Sta. Bul. No. 107 (1897), p. 218.

[3] Texas Sta. Bul. No. 77 (1905), p. 20.

particular, by selection. The plant is cone-shaped, the lower branches about six inches from the ground being longest and next above gradually growing shorter until the top is reached.

The leaves are large, three to six inches long, and two to five inches wide. The first ones are entire and somewhat heart-shaped; subsequent leaves are three to five, rarely seven, lobed. The midvein, and sometimes the lateral veins, bears a dark green gland near its base, which may serve as a variety characteristic. All vegetative portions of upland cotton are covered with short hairs.

405. Flowers.—The flowers are regular, having five small, united sepals and five large petals. The flowers open at sunrise

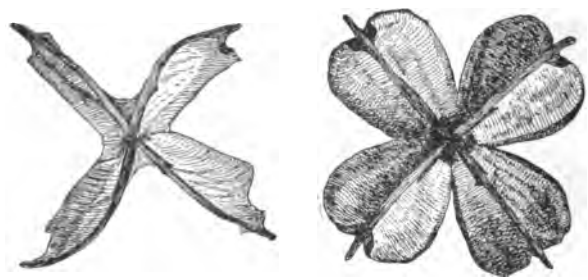


Cotton boll: longitudinal and cross-sections show the arrangement of seeds; the cross-section on the right shows the division into carpels
(From photo by Bennett)

or just before. In upland cotton the petals, when they open, are creamy-white, and in sea island, bright yellow. During the day they turn pink or bright red. The flowers close late in the day, and never open again; hence, if cross-fertilization takes place, it must be during the single day that the flower is open. The corolla falls, but the calyx is persistent, although small and inconspicuous. The young capsule or boll, surrounded by the three bracts or involucre, is referred to by farmers as squares.[1]

The stamens are many, monadelphous, and united at the base with the petals; the anthers are one-celled. The styles are united, but are distinct above; thus the stigma appears three to five cleft, depending on the number of cells or carpels into which the pistil is divided.

406. Bolls.—The pistil grows into a large fruit or capsule, usually called boll, about the size and somewhat the shape of



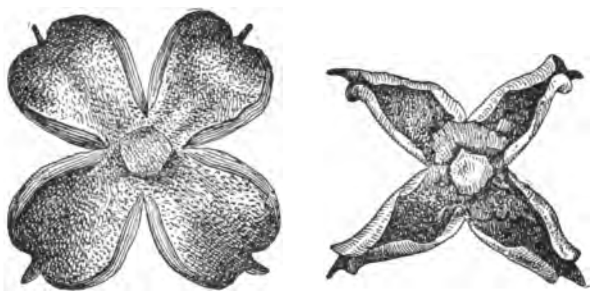
Inside structure of cotton bur. The small, thin bur opens flat and twists backward, removing all support to the locks which fall out. The big, tough bur does not fold back and leave the locks unsupported
(From photo by Bennett)

a hen's egg, except that it is distinctly pointed at the free end. The bolls vary from 1.5 to 2.5 inches in length, and from 1.25 to 1.75 inches in width. The weight of the content of 100 bolls may vary with the variety from 0.75 to 2 pounds, or the number of bolls required to produce one pound of seed cotton may vary from 50 to 130. Varieties requiring from 50 to 65 bolls to make a pound of cotton may be considered as having large bolls, those with 65 to 80 medium bolls, and those with 80 to

[1] The terms, form and squares are used loosely and to some extent interchangeably. Frequently these words are used to apply to the leafy bracts and the enclosed bud, flower, or small boll, while in other cases the word form is applied to the bud only; that is, the flower before it opens.

130 small bolls. The large bolls are desirable for picking, and are less liable when open to drop the cotton.[1] As the average of twelve years' experiments, larger bolls gave the larger yields of lint, but the differences are not marked.[2]

There are three to five, under cultivation usually four, lobes or cells. These cells extend from the base of the boll to the apex. When ripe the cells open by separating along their central axis, and at the same time splitting down the middle of the back, thus exposing the dark-colored seeds covered with the



Outside structure of cotton bur. The small, thin bur opens flat and twists backward, removing all support to the locks which fall out. The big, tough bur does not fold back and leave the locks unsupported
(From photo by Bennett)

usually pearly white hairs or fibers for which the plant is primarily cultivated. This method of opening produces three to five, usually four, more or less three-sided valves collectively called the bur with characteristically curved, pointed tips. These valves vary in shape. The small, thin burs open and twist backward, removing the support to the locks or seed cotton, while the large, tough burs do not turn back, and thus the locks are supported.[3]

The number of bolls per plant may vary with variety, soil, climate and cultural conditions from few or none to seventy

[1] Texas Sta. Bul. No. 75 (1904), p. 10.
[2] Georgia Sta. Bul. No. 70 (1905), p. 70.
[3] Texas Sta. Bul. No. 75 (1904), p. 12.

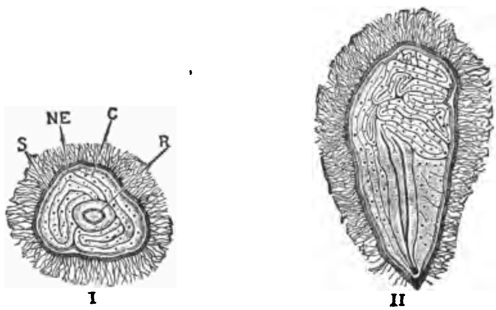
or more. The number of bolls does not depend alone on the size of the plant, but on the number of branches and distance between the leaves upon the branches, usually referred to as the joints. Since the branches arise in the axils of the leaves upon the main stem and the flowers arise in the axils of the leaves on the secondary or tertiary branches (branches of branches), short-jointed plants are, in proportion to size, most productive.

407. Seed.—The seeds are somewhat angular, about three-eighths inch long and three-sixteenths inch wide, oblong oval, pointed at the hilum end with the crown or free end enlarged and rounded. The seed coat is brown or black. The number of the seeds of upland cotton may vary from about 3,000 to nearly 6,000 to the pound. The seed of sea island cotton is slightly smaller. Seed requiring 3,500 or less to the pound (13 grams per 100) may be considered large; those requiring 4,500 or more to the pound (10 grams per 100) may be considered small. The legal weight per bushel of upland cotton seed varies from 28 to 33.3 pounds, usually 30 or 32 pounds, and sea island cotton seed from 42 to 46 pounds, usually 44 pounds.

The seed cotton in each lobe or cell is called a "lock" of cotton. Each lock contains six to ten seeds, hence each boll may contain from 20 or less to 50 or more seeds. Individual plants may produce from 500 to 2,000 seeds. The seeds of upland cotton are covered with a dense "fuzz," or short lint, which gives the seeds a whitish, brownish, or green tint. The seeds of sea island cotton are nearly or quite naked, thus exposing the black seed coat.

The seed consists chiefly of the testa or hull and the embryo or meat. In addition to these, but forming only a small portion of the seed, are the nucellus, a thin skin just within the hull, and just within this the endosperm, a layer of cells containing aleurone grains. Throughout the nearly white embryo are the so-called resin cavities containing a dark-colored secretion, which are plainly visible on the new leaves when the seed germinates.

Seeds as they come from the gin may be divided into three parts as follows: short lint or linter, 10 per cent; hulls 40 per cent; and kernel or embryo 50 per cent. The kernel contains 40 per cent. of oil, leaving when the oil is entirely removed,

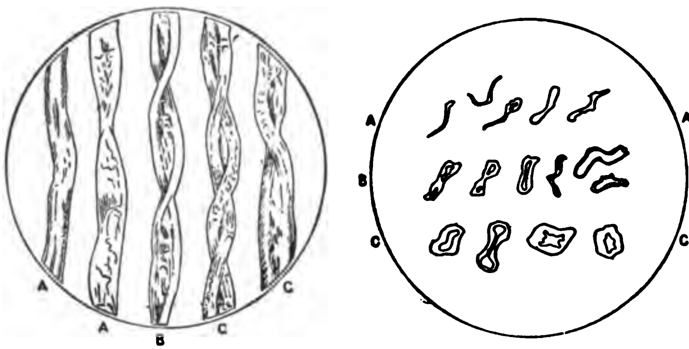


Cotton seed. I. Transverse section. II. Longitudinal section. *S* testa; *NE* perisperm and endosperm; *C* cotyledons; *R* radicle
(After Winton)

60 per cent. of meat or 30 per cent. of the whole seed as it comes from the gin.

408. Lint.—A cotton fiber consists of one elongated cell, which when ripened has been flattened into a much twisted ribbon-like filament which has been likened to a collapsed and twisted piece of rubber hose. Because of the twist, cotton is distinguished from other textile fibers. The number of twists are said to vary from 300 to 500 per inch. The number and uniformity of the twists dependent on the ripeness of the fibers affect materially the spinning qualities and hence the commercial value of the fiber. In every lot of lint, three classes of fibers are recognized: ripe, half ripe, and unripe.

The longest fibers occur at the top of the seed; the shortest at the base. The lint of cotton may vary, depending on the type, from one-half inch to two and a half inches in length. As grown in America, short staple upland cotton usually varies from seven-eighths to one and one-fourth inches. When the staple of upland cotton exceeds one and one-fourth inches, it is classed as long staple upland cotton. Cotton of the latter type ranges from one and one-fourth to one and five-eighths inches, while sea island cotton ranges from one and one-half to two and one-half inches, one and three-quarters to two inches



Cotton fibers in longitudinal and cross section: *AAA* unripe fibers; *BB* half-ripe fibers *CCC* fully ripe fibers (After Evans)

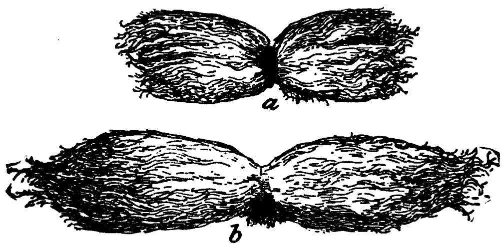
being the usual length. The production of long staple upland and of sea island cotton is insignificant compared with that of short staple upland. In view of the demand for Egyptian cotton, the United States Bureau of Plant Industry believes that planters should give more attention to the raising of long staple upland cotton.[1]

The mean diameter of short staple cotton is about 0.0008 inch and of sea island cotton about 0.0006 inch. The fiber is somewhat larger in the middle, ends abruptly where it is attached to the seed and is tapering and pointed at its free end. In short staple cotton there are about 140 million individual fibers to the pound. It is stated that if a cotton fiber were magnified until it was one inch in diameter it would be over 100 feet long, and that

[1] U. S. Dept. Agr. Yearbook 1903, p. 121.

if the separate fibers in a pound were placed end to end they would reach 2,200 miles.

The tensile strength or breaking strain of the cotton fiber may vary from about 2.5 to 15 grams, depending on the fineness and ripeness of the fiber.[1] Hilgard found American upland cotton to vary from 4 to 14 grams. Silk has a greater and wool a less tensile strength than cotton in proportion to the diameter



Cotton seeds with lint attached, illustrating types of long staple cotton. *a* Imported Mit Afifi (Egyptian), *b* ordinary sea island
(After Webber)

of their respective fibers. The tensile strength of various fibers in relation to their size and therefore their strength in relation to the weight of garment may be expressed by the "breaking length," which means the length of fiber which would break of its own weight.

Table Showing Length of Fiber Which Will Break of Its Own Weight

Fiber	Breaking length in miles
Wool	5.1
Jute	12.4
Ramie or China grass	12.4
Flax	14.9
Cotton	15.5
Hemp	18.6
Manila hemp	19.8
Silk	20.5

[1] In order to get concordant results, care must be taken concerning the method of suspension.

This table shows that in proportion to its weight, cotton has three times and silk four times the tensile strength of wool. The value of hemp and manila hemp for cordage is also emphasized. The full tensile strength of fibers is not utilized when made into cordage or fabrics. In the case of cotton only 20 to 25 per cent. of the total breaking strain is realized when spun into yarn.

Vegetable fibers in general are less elastic and less hydroscopic than wool or silk. In this respect raw cotton is no exception, although the moisture content, normally seven to eight per cent., does vary with the atmospheric conditions, and hence is a factor in the purchase as well as in the spinning of cotton. Although raw cotton is rather non-absorbent to water, it becomes extremely absorbent when the waxy and fatty matters are removed.

409. Structure of Fiber.—Aside from its natural impurities consisting chiefly of pectic acid, coloring matter, wax, oil, and proteid matter, the cotton fiber may be divided into three parts: (1) the main cell wall, probably pure cellulose and constituting 85 per cent. of the fiber; (2) an outer membrane or skin; and (3) an inner membrane or wall of the central canal. Both of these membranes are less soluble in a solution of ammonio-copper oxide than the cell wall. The former is probably modified cellulose, while the latter is a thin layer of dried protoplasm which was contained in the living fiber. Some authorities recognize a secretion within the canal itself corresponding to the pith of a quill.

When a fiber is treated with a solution of ammonio-copper oxide the fiber swells, but not throughout its whole length. According to some authorities the ligatures which prevent the swelling of the cell walls at intervals are distinct from the outer membrane or skin, while according to others they are believed to be sections of the outer skin which have resisted the action of the reagent.

410. Qualities of Lint.—Some of the factors which give cotton value as compared to other fibers, particularly vegetable fibers, are its cheapness, uniformity, flexibility, and wearing quality. The wearing quality is doubtless due to the fact that each fiber is a single cell and therefore the fiber is less readily disintegrated by wear or the application of alkalis, soap and the like in washing. It is adapted to nearly all forms of woven fabrics, and is spun into yarn with greater ease and rapidity than any other vegetable fiber.

The factors which give one sample of cotton spinning value compared to another are length, uniformity of length, fineness, strength, and the number and uniformity of twists. As lint occurs in commerce the purity and color of the sample are important factors.

411. Linters.—In addition to the fibers just mentioned, known in commerce as lint, the seeds of upland cotton are covered with a dense undergrowth of short fuzzy fibers. These short fibers in ginning mostly remain with the seed. They are, however, more or less removed with the lint and thus materially affect the commercial value of the latter. This short fiber, which constitutes about 10 per cent. of the total weight of the fiber, is known usually as "linters" before it reaches the manufacturer and afterwards as "neps," although neps may consist also of broken fibers caused by the manufacturing process.[1]

412. Proportion of Parts.—The table following shows the percentage of parts of the upland cotton plant as obtained by the Georgia, Tennessee, and Alabama stations. The results of the Georgia Station are the proportion of the air-dry parts, while in the Tennessee and Alabama stations the proportion of the water-free substance is given. The difference in the mode of expressing the results explains, in part, probably the difference in the result obtained as given on the next page.

[1] Matthews: Textile Fibres, p. 129.

Table Showing Percentage of Parts of Upland Cotton Plant

Parts	Georgia Station	Tennessee Station	Alabama Station
Lint	9.8	10.6	12.1
Seed	19.8	23.0	20.5
Burs	12.7	14.2	14.7
Leaves	12.7	20.3	22.9
Stems	35.2	23.1	24.5
Roots	9.8	8.8	5.3
	100.0	100.0	100.0

In general there are two pounds of seed produced for each pound of ginned lint. Short staple upland seed cotton producing 35 to 38 per cent. of lint may be considered high, 29 to 32 per cent. low, while above 38 or below 29 per cent. may be considered very high or very low respectively. Sea island cotton formerly produced only 20 per cent. of lint, but varieties have been selected until 30 or more per cent. is obtained in some instances. Long staple upland cotton generally ranges from 27 to 32, usually less than 30 per cent.

413. Composition.—The following table gives analyses of plant, seed and lint of upland cotton grown at the Tennessee Station:[1]

Table Showing Analysis of the Upland Cotton Plant

Analysis	Plant	Seed	Lint
Water	7.36	7.04	6.74
Ash	5.81	3.29	1.65
Protein (N x 6.25)	9.13	19.18	1.50
Crude fiber	30.94	22.43	83.71
Nitrogen-free extract	42.84	26.44	5.79
Fat	3.92	21.62	0.61
	100.00	100.00	100.00

[1] U. S. Dept. Agr., O. E. S. Bul. No. 33 (1896), pp 120, 122, 123.

The lint is not pure cellulose, but contains also small quantities of protein, the remnant of the living cell and some extractive matter. The fat probably is absorbed from contact with the seed. The seed is characterized by its high content of protein and fat in which regard it is somewhat similar to the seeds of three other cultivated but somewhat minor crops, namely, flax, peanut, and soy bean. The following table shows the maximum and minimum protein and fat content as determined by American analyses for the air-dry seeds of these four plants:

Table Showing Protein and Fat in Seeds of Four Plants

Plant	Protein		Fat	
	Minimum	Maximum	Minimum	Maximum
Cotton	14.5	23.7	18.9	29.1
Flax	20.3	25.8	31.7	37.9
Peanut	25.7	28.0	35.7	47.4
Soy bean	26.3	40.2	12.3	19.0

414. Ash.—The following table shows the ash constituents in the whole plant, seed and lint:

Table Showing Ash Content of Cotton

Analysis	Whole plant	Seed	Lint
Phosphoric acid	0.9	1.3	0.1
Potash	2.5	1.2	0.5
Soda	0.3	0.2	0.1
Lime	2.8	0.3	0.2
Magnesia	0.8	0.6	0.1
Ferric oxide	0.3	0.1	0.02
Sulphuric acid	0.6	0.1	0.06
Chlorine	....	....	....
Insoluble	1.0	0.1	0.05

The Tennessee and Alabama stations have determined the total amount of dry matter in the whole plant, including roots, and the chemical constituents contained therein for each 100 pounds of lint produced, thus indicating the demands made upon the soil for plant food.

Dry Matter and Chemical Constituents for Each 100 Pounds Cotton Lint

Analysis	Tennessee Station	Alabama Station
	Lb.	Lb.
Dry matter	847.0	824.0
Nitrogen	20.7	13.0
Phosphoric acid	8.2	4.4
Potash	13.1	10.4
Lime	12.6	13.4
Magnesia	4.8	....

415. Collateral Reading.—J. M. Matthews: The Textile Fibres, pp. 124-138, 139-155. New York: John Wiley and Sons, 1904.

William H. Seaman: On the Identification of Fibers. In U. S. Dept. Agr., Fiber Investigations Rpt. No. 9: A Descriptive Catalogue of the World, pp. 352-8.

C. B. Williams: Cotton Plant. The Bulletin, North Carolina Dept. Agr. (September, 1906), pp. 3-16.

XVIII

FIBER CROPS

COTTON

Varieties and Improvement

416. Species.—Index Kewensis recognizes 24 species of cotton with 88 synonyms. Linnaeus classified cotton into three species: *barbadense, herbaceum* and *arboreum,* the latter being the tree cotton of Asia.[1] Under this classification sea island, Egyptian and Peruvian cotton would fall within the first-class and American upland and India cotton would fall in the second class. It may be doubted whether the wild prototypes of the cultivated species have ever been recognized.

"The great variability and the tendency to hybridize make it difficult to determine to which species a given plant may belong. No cultivated plant responds so quickly to ameliorated conditions of soil, climate, and cultivation as the cotton plant, and to this fact is due much of the confusion as to species and varieties. Another factor entering into the confusion is the imperfectly known types that have been described as species. It has been stated that some of the species widely cultivated are wholly unknown in a wild state, and some of the specimens described by Linnaeus were in all probability from plants that had long been in cultivation. The work of establishing the origin of the cultivated species has been still further complicated by the exchange of seed from country to country that has been going on for at least four centuries.[2]

In the classification given below the United States Bureau of Plant Industry is followed.[3]

[1] Some of the cotton grown in Peru is of the *arboreum* type.
[2] U. S. Dept. Agr., Off. Expt. Sta. Bul. No. 33 (1896), p. 68.
[3] U. S. Dept. Agr. Yearbook 1903, p. 388.

417. American Upland Cotton.—(*Gossypium hirsutum* L.).—This species is native of the American tropics. The plant is a perennial but is cultivated as an annual. It is characterized by the species having in addition to the pearly white lint one-half to one and a half inches long a dense covering of short lint varying in color from whitish or brownish to greenish. This is the chief kind of cotton raised in America and hence in the world.

American upland cotton
(From photo by Dewey)

418. India Cotton (*G. herbaceum* L.).—This species is native of southern Asia, and according to some writers synonymous with the former. The plants differ from American upland cotton in their more slender, less woody stems with leaves having rounded instead of sharp-pointed lobes, and in the smaller and more spherical bolls. The lint of some varieties is glossy white, of others dull, of some yellow, and still others golden brown. It is generally coarser and shorter than American upland cotton, ranging from one-half to an inch in length. It is cultivated in southern Asia.

419. Sea Island Cotton (*G. barbadense* L.).—This species was found in the West Indies when Columbus first visited those islands. The plant differs from upland cotton in its larger growth, three to eight feet high, with longer and more flexible branches, more deeply lobed leaves, bright yellow instead of white flowers, and sharp-pointed bolls, having three instead of four or five divisions or locks. The seeds are black or dark brown, and are not covered with a persistent fuzz. The lint is 1.4 to 2 inches, sometimes 2.5 inches long; finer and usually softer and more lustrous than upland cotton.

India cotton
(From photo by Dewey of herbarium specimen)

Sea island cotton yields less per acre and costs more to pick and gin, but commands a higher price, usually ranging from two to fifteen cents higher, than upland cotton. It is grown chiefly on islands and adjacent mainlands of South Carolina and Georgia, although to some extent on sandy soils of the interior of Georgia and northern Florida.

420. Egyptian Cotton.—This type is considered to be the same type as sea island modified on account of cultivation on the irrigated lands of Egypt where scarcely any rain falls. Many generations of growth under these conditions and possibly some by hybridization with India cotton have developed certain qualities of lint especially adapted to the manufacture of hosiery yarns and mercerized goods. Varieties have been brought to the United States and are being grown by the United States Bureau of Plant Industry to adapt them to the climatic and soil conditions.[1] The opinion is expressed, however, that

[1] U. S. Dept. Agr. Yearbook 1902, p. 381.

the demand for this grade of cotton can be met by the American planter by growing long staple upland cotton.

421. Peruvian Cotton (*G. peruvianum* Cav.).—This cotton is characterized by the seeds in each lobe of the capsule clinging together in a compact cluster. Seeds are similar to sea

Cotton bolls. On left American upland; in center sea island; on right India cotton boll (After Dewey)

island cotton. Lint shows a wide variation in color and texture, white, brown, reddish, rough and harsh or smooth and soft. The staple is mostly shorter, coarser and more wiry than American upland cotton. Some varieties have a lint which, when made into fabrics, closely resembles wool. The plant is perennial, but only the growth from the second and third years is utilized.[1] Peruvian cotton is raised chiefly in Peru and Brazil.

422. Classification of Varieties.—Since the classification of cotton into species is so diffcult, it is not surprising that the classification of varieties is equally difficult. There are at least 150 so-called varieties of upland cotton, 93 having been tested at the Alabama Station. Varieties of cotton have not been for the most part carefully described which, together with the tendency of the plant to vary with its environment, makes great confusion in the naming of varieties.

[1] Matthews: Textile Fibres, p. 116.

The Alabama Station has classified short staple upland cotton into six classes to which it adds long staple upland varieties as a seventh class, as follows:

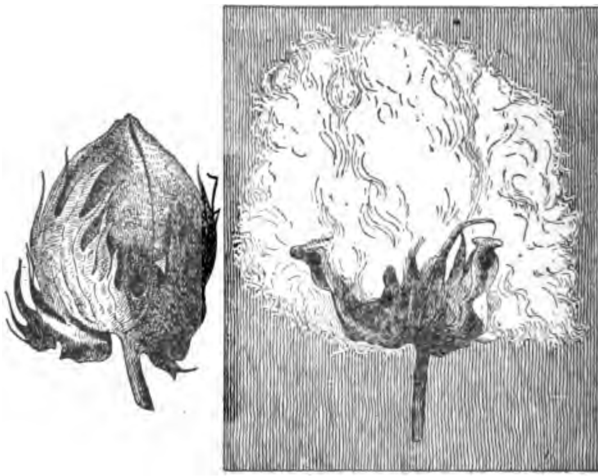
- Upland Cotton
  - Short Staple
    - Cluster varieties or Dickson type
      - Dickson
      - Jackson
      - Welborn
    - Semi-cluster varieties or Peerless type
      - Boyd
      - Cummings
      - Drake
      - No. 28 N
      - Hawkins Prolific
      - Hawkins Jumbo
      - Herndon
      - Minor
      - Norris
      - Tyler
    - Rio Grande varieties or Peterkin type
      - Peterkin
      - Peterkin Limb Cluster
      - Texas Wood
      - Wise
    - Short Limb varieties or King type
      - King
      - Lowry
      - Parks
      - Herlong
    - Big Boll varieties or Duncan type
      - Banks
      - Christopher
      - Coppedge
      - Culpepper
      - Duncan
      - Grayson
      - Jones Improved
      - Lee
      - Russell
      - Scroggins
      - Strickland
      - Texas Storm Proof
      - Thrash
      - Truitt
      - Pruitt Premium
    - Long Limb varieties or Petit Gulf type
      - Ellis
      - Gunn
      - Petit Gulf
      - Cheise
  - Long Staple
    - Long Staple varieties or Allen type
      - Allen Hybrid
      - Allen Improved
      - Cook (W. A.)
      - Doughty
      - Griffin
      - Improved Long Staple
      - Matthews
      - Moon

The lines of demarcation between these groups are not always clear and distinct, one group often merging into another by an almost imperceptible gradation.[1]

[1] Alabama Station Bul. No. 107 (1899), p. 202.

CLASS I. CLUSTER VARIETIES OR DICKSON TYPE.—The most striking characters are the absence of long wood limbs, except at the base, and the tendency of the bolls to grow in clusters. The plant is usually tall, slender and erect. The bolls and seed are usually small or more rarely medium; seeds thickly covered with usually whitish fuzz, rarely any brownish or greenish tinge. Varieties moderately early maturing. Percentage of lint ranges from 32 to 34 per cent.

CLASS II. SEMI-CLUSTER VARIETIES OR PEERLESS TYPE.—Similar to preceding type, but having along the main stem very short limbs above the base



Mature unopened and opened long staple upland cotton bolls; variety Allen Improved. Two-thirds natural size
(From photo by Webber)

limbs, which latter are usually of medium length. Bolls variable in size; seeds usually medium in size, well covered with fuzz of many shades, whitish, greenish, or brownish. Varieties early to medium maturing.

CLASS III. RIO GRANDE VARIETIES OR PETERKIN TYPE.—This type is characterized by its high percentage of lint, 35 or more per cent., and the absence of fuzz or nearly so except at the tip end. Plants well branched, medium size. Bolls small; black seeds quite small. Varieties medium maturing.

CLASS IV. SHORT LIMB VARIETIES OR KING TYPE.—Plants small, well branched throughout; limbs short; bolls small, seed medium and thickly covered with fuzz usually brownish, more rarely greenish. Percentage of lint 32 to 34. Varieties characterized by extreme earliness.

CLASS V. BIG BOLL VARIETIES OR DUNCAN TYPE.—This type is distinguished for the large size of its bolls, 51 to 68 being required to produce a pound of seed cotton. Seed large, covered usually with a thick fuzz, variable from whitish to deep green. Per cent. of lint 30 to 33. Upper limbs often short. Bolls never two-clustered. Varieties noted for late maturity and vigorous growth of stalk.

CLASS VI. LONG LIMB VARIETIES OR PETIT GULF TYPE.—Plants grow to large size, have long limbs and straggling appearance. Bolls and seed medium to large, latter covered with fuzz of various shades. Per cent. of lint low to medium. As a class poorly suited to upland soils.

CLASS VII. LONG STAPLE VARIETIES OR ALLEN TYPE.—Distinguished for length of lint, usually measuring from one and one-eighth to one and five-eighths inches with usually less than 30 per cent. of lint. Plants similar to Class VI. Bolls medium, long, slender, and very pointed. Seeds medium to large, usually densely covered with almost pure white fuzz with no trace of green; more rarely naked seeds distinguished from Class III by larger size. Varieties late maturing. The varieties of this type are believed to have been obtained by selecting hybrids of sea island and upland cotton. Chiefly cultivated in the rich alluvial soils of the Yazoo Delta in Mississippi.

423. Standard and Recommended Varieties.—The Alabama Station recommends Peterkin and Truitt as standard and safe medium maturing varieties; for early varieties King, Welborn, Dickson and Peerless are recommended. Other productive varieties are Jones Improved, Allen Long Staple, Hawkins, Herlong, and Hunnicutt.[1] In 1904 the different types of cotton yielded as follows:[2]

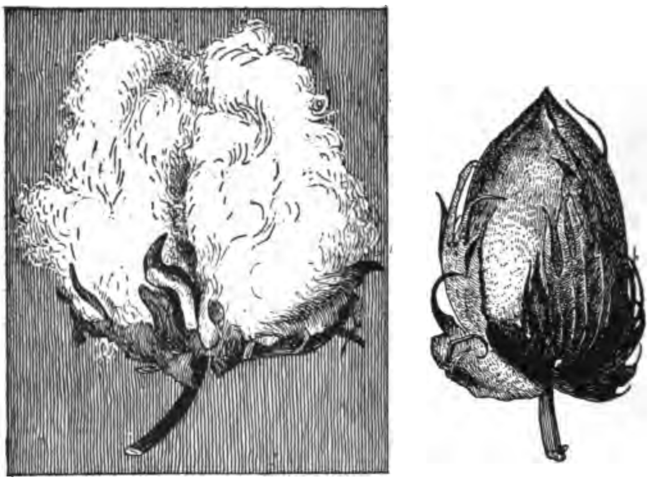
Table Showing Yield of Upland Cotton

Type	Yield of lint, lb.	Yield of seed, lb.
Semi-cluster	468	867
Rio Grande	601	936
Short Limb	471	835
Big Boll	466	905
Long Staple	400	829

At the Texas Station the largest yields of seed cotton during three years were obtained from Beck's Big Boll, Dixon's Im-

[1] Alabama Sta. Bul. No. 107 (1899), p. 209.
[2] Alabama Sta. Bul. No. 130 (1905), p. 8.

proved, Peerless, Surefruit, and Cochran's Prolific.[1] Cook's Improved, Layton's Improved, and Moss' Improved, the latter two similar to Peterkin's Improved, have given satisfactory yields at the Georgia Station. Schley, a variety produced by the Georgia Station, by selection, has given good results.[2] In South



Mature unopened and opened long staple upland cotton bolls; variety Griffin. Two-thirds natural size
(From photo by Webber)

Carolina, Texas Oak, Boles Improved Prolific and Drake Cluster gave the largest yield of lint at the home station; Jones Improved in the Upper Pine Belt Region, and African, King and Truitt at Beech Island.[3]

The United States Bureau of Plant Industry mentions Griffin as one of the best long staple upland cottons now grown.[4] Other varieties of long staple cotton are Allen Long Staple,

[1] Texas Sta. Bul. No. 50 (1899), p. 3.
[2] Georgia Sta. Bul. No. 70 (1905), p. 66.
[3] South Carolina Sta. Bul. No. 42 (1895), p. 8.
[4] U. S. Dept. Agr. Yearbook 1902, p. 380.

Cook, Commander, Moon, Peeler, Southern Hope, and Sunflower.[1] This Bureau distributed in 1903 the following varieties for planting: short staple upland cotton; Parker, Jones Improved, Excelsior and King: long staple upland cotton; Allen Improved and Griffin: sea island; Seabrook and Rivers.[2] The last variety is considered resistant to the wilt disease.

424. Desirable Variety Characters.—The quantity and quality of lint produced are the chief considerations in the raising of cotton, yet with the present demand for the seed the yield of seed cannot be ignored. The qualities to be sought in cotton, therefore, are yield of seed and of lint; length, fineness, and strength of staple as well as uniformity of length, the latter being an important commercial quality; time of maturity; and resistance to diseases and to storms. (428) While certain characteristics of the plant described below influence yield, the inherent quality of productiveness as determined by weight of product on a given area is of the first importance in making selections.

The yield of lint depends on the percentage of lint to seed cotton and the weight of seed cotton. Small seed is usually an indication of high percentage of lint. The size of seed as a variety characteristic does not seem to be related to the yield of seed cotton, but the Alabama Station found that large seed produced a heavier yield of seed cotton than small seed of the same variety.

The weight of seed cotton seems to be dependent, in general, upon the size of the bolls, the number of bolls per plant, and the number of plants per acre. In proportion to size, short jointed plants will produce more bolls than long jointed ones. In general, the total weight of seed cotton varies more according to variety and environment than does the percentage of lint, hence as a rule the amount of seed cotton rather than the percentage of lint is the more important character; although, of course, of

[1] Ibid., p. 126.
[2] U. S. Dept. Agr., Bu. Pl. Ind. Bul. No. 25, p. 47.

two varieties yielding the same amount of seed cotton, the one having the highest percentage of lint will be preferable, other things being equal.

In general, medium maturing varieties produce the largest yield of seed cotton, but early maturing varieties may be more desirable in order to increase the quality of the cotton, which in later varieties becomes stained from the rains. Where the boll weevil does damage early varieties are desirable because such varieties are less injured by the weevil, since the number of weevils increases as the season advances.

The Georgia Station has tested 20 to 30 varieties annually for twelve years, and by dividing these into two classes—namely, those which gave the best results and poorest results based on lint at eleven cents per pound and seed at eighty cents per hundred pounds—it was found that the per cent. of lint in the best half was 34.7 and in the poorest half 32.5; that the number of bolls to the pound of seed cotton was for the best half 70.1 and for the poorest half 74.7; that the number of seeds per pound of seeds was for the best half 4,144 and for the poorest half 4,126 The best half yielded 56.4 per cent. of its cotton in the first two pickings, while the poorest half yielded 58.8 per cent. of its cotton.[1]

While in general early varieties have smaller bolls than later maturing varieties, and thus are likely to yield less cotton the Texas Station believes that by selection early varieties with large bolls may be produced.

425. Crossing.—Cotton flowers are large and attractive, and are much visited by bees and other insects. The flowers, however, are abundantly self-fertile and set seeds normally when covered with paper bags. Under ordinary field conditions observations indicate that from 5 to 10 per cent. of seeds are cross-fecundated.[2] While cross-fertilization is not so great, therefore

[1] Georgia Sta. Bul. No. 70 (1905), p. 70.
[2] U. S. Dept. Agr. Yearbook 1902, p. 380.

as in maize and some other plants, it is sufficiently important to be considered in attempting to maintain pure strains or in making improvements by selection. Pollen is mainly carried by bees. Practical isolation may be secured by planting a quarter or half a mile from other cotton, particularly if surrounded by woods, although for accurate breeding work greater precaution may be necessary.

Where crossing is feared from undesirable types mixed with the type it is desired to propagate, this may be prevented by going through the fields as soon as the lower flowers appear and removing all plants showing the undesirable characters. Seed may then be selected from the upper bolls, which were fertilized after the objectionable plants had been removed.

426. Seed Selection.—With cotton as with most other crops, evidence is accumulating to show that the best results are obtained by selecting where it is regularly grown rather than in the change of seed. (C. A. 40, 41, 116, 277, 393) Probably half the cotton seed planted is taken at random from the public gin. Some of the more careful growers, however, send trusted employees through the field at the second, and if necessary to obtain sufficient seed also at the third, picking who select the seed cotton from the most productive plants of the type desired. The first and fourth pickings are not generally considered so desirable for seed. The seed cotton thus obtained is ginned separately. By the use of such seed much has been accomplished in improving the general yield and quality of cotton. Cotton degenerates easily and improves rapidly under careful selection.

427. IMPROVEMENT OF COTTON.—For those who wish to make more rapid and definite progress in the improvement of cotton the United States Bureau of Plant Industry recommends the following method which has been practised successfully for several years by some growers of sea island cotton, the staple having been increased from 1.75 to 2.5 inches by this method.[1] This method requires four years of selection to secure seed for general planting. The following diagram shows the steps to be taken with each plant selected.

[1] U. S. Dept. Agr. Yearbook 1898, pp. 358-62.

First Year—

The first year five[1] or more plants are selected from any field of the type it is desired to improve, the larger the field and the more rigid the selection the better. The diagram assumes for clearness that only one plant has been selected, but it is important that more than one plant be taken, since frequently a fine appearing plant fails to transmit its characteristics.

Second Year—

Five hundred or more seeds are selected from each plant and planted the next year. When these plants reach the proper stage of maturity the entire progeny should be examined to see whether the plant selected the first year shows strong transmitting power. If satisfactory, select several of the best

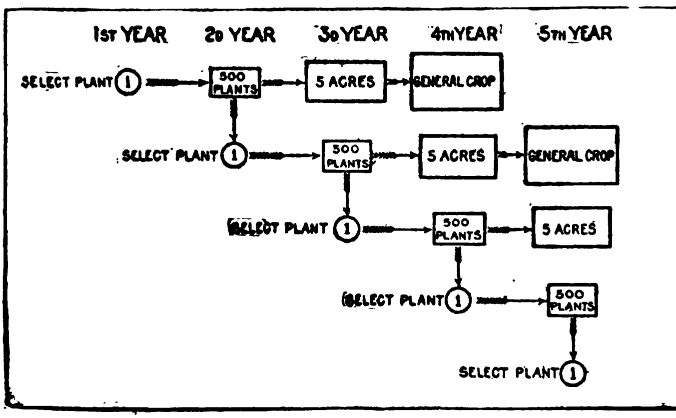


Diagram illustrating method of selecting cotton
(After Webber)

plants; if not, reject all. From the specially selected plants of this second generation select a single plant to be handled exactly in the same way as the selections made the first year. The seed from the remaining selected plants are retained to plant a seed patch of five acres in the third year.

Third Year—

The third year there will be grown 500 or more plants of each of the individual selections, and as many five-acre seed patches for seed for general planting as there were individuals of the first year whose progeny was considered worth propagating.

Fourth Year—

This year there will be seed for general planting from the five-acre seed patches of the previous year; five-acre seed patches from the specially selected

[1] In the careful pedigree breeding of ordinary cottons probably 25 or more superior plants should be selected.

individuals of the second year; and 500 or more plants of each of the individual selections.

The method here outlined is to be continued indefinitely, as it is only by the careful and continuous selection that high bred strains can be kept up to a state of efficiency, and if for any reason is interrupted there is a general and rapid decline.

428. Score Card.—For careful comparisons in making selections a score card arranged to compare and emphasize the points especially sought is desirable. The United States Bureau of Plant Industry uses the score on p. 338 in judging hybrids of sea island and upland cotton for the purpose of securing cotton for cultivation in upland regions which will have long staple, big bolls, opening well and easy to pick, and black seed. In this case all plants not having black seeds were rejected.[1]

429. Scale of Qualities.—In place of a score card, such as suggested above, the Texas Station proposes a set of maximum and minimum qualities, as follows:

For Early Fruiting.—The first fruit limb must not be higher than the fifth joint above the seed leaf joint. The first primary or wood limb must not be above the fifth joint, and the number of primary limbs should not exceed four.

For Rapid Fruiting.—The joints on the main stem, fruit limbs, and primary limbs must not exceed three inches. Fruit limbs should grow in succession at each joint of the main stem and primary limbs, and should be continuous in growth for continuous fruiting.

For Productiveness.—The bolls should not be less than 1.5 inches in diameter. The per cent. of limb to seed cotton should not be less than 33.3. The rate of growth is very important, and, therefore, the larger the plant of the type, the greater is its inherent rate of growth, its earliness, rapidity of fruiting, and yield.[2]

430. Influence of Environment.—"All evidence indicates that the seed produced by plants grown on good soil under the best conditions produces in its turn the best and most vigorous seed. It is thus desirable to plant the selection field on good rich soil of the same kind on which the crop is to be generally cultivated. If the general crop is to be grown on a light, sandy soil, it would of course be wrong policy to place the selection field on a rich, heavy loam. The soil should be of the kind used for the general fields, but unexhausted by previous cultivation. It is also desirable that the selection

[1] U. S. Dept. Agr. Yearbook 1902, p. 376.

[2] Texas Sta. Bul. No. 79 (1905), p. 8.

Score of Points Used in Judging Sea Island and Upland Cotton

Size of bolls, 15 points	Very large, 15 points
	Large, 14 points
	Medium, 12 points
	Small, 8 points
	Very small, 3 points
Length of lint, 20 points	2 inches, 20 points
	1⅞ inches, 19 points
	1¾ inches, 18 points
	1⅝ inches, 17 points
	1½ inches, 15 points
	1⅜ inches, 10 points
	1¼ inches, 5 points
Fineness of lint, 10 points	Very fine, 10 points
	Fine, 8 points
	Medium, 6 points
	Coarse, 3 points
Yield, 20 points	Excellent, 20 points
	Good, 18 points
	Medium, 15 points
	Light medium, 10 points
	Light, 5 points
Uniformity in length of lint, 7 points	Excellent, 7 points
	Good, 6 points
	Fair, 4 points
	Poor, 2 points
Strength of lint, 10 points	Very strong, 10 points
	Strong, 8 points
	Medium, 8 points
	Weak, 3 points
Per cent. of lint, 18 points	33 + per cent., 18 points
	31–32 per cent., 17 points
	29–30 per cent., 16 points
	27–28 per cent., 15 points
	25–26 per cent., 10 points
	23–24 per cent., 5 points

field should be well fertilized and cultivated, as every means should be used to develop the best plants and the best seeds."[1]

431. Collateral Reading.—H. J. Webber: Improvement of Cotton by Seed Selection. In U. S. Dept. Agr. Yearbook 1902, pp. 365-386.

C. B. Williams: Cotton Plant. The Bulletin, North Carolina Dept. Agr. (September, 1906), pp. 16-27.

[1] U. S. Dept. Agr. Yearbook 1902, p. 371.

XIX

FIBER CROPS

COTTON

Climate and Soils

432. Distribution.—Cotton production is limited practically to the area south of the thirty-seventh parallel of latitude, while the larger and most intensive production is located south of the thirty-fifth parallel. In Asia the limit of cultivation extends somewhat farther north. The possible production of cotton is almost unlimited, since the largest land surface of the globe is between the thirty-seventh parallels of latitude north and south, in all habitable sections of which cotton can be more or less successfully grown. Within this area, however, its economic production is limited by the amount and distribution of sunshine and rainfall, as well as by temperature. It is now grown chiefly between parallels 20° and 37° north latitude.

433. Temperature.—The cotton plant is extremely sensitive to temperature conditions. The plant requires four or five months of uniformly high temperature during which time it makes its vegetative growth. A cold spell during this period is liable to cause fruiting and is not desirable. After having made its vegetative growth, two or three months of cooler weather, with a greater range in daily temperature, are desirable to bring about fruiting and ripening.

For the best production of cotton there should not be killing frosts later than April first nor earlier than November first, and when fifteen days may be subtracted and added to these dates the conditions are considered even more favorable. In the more

Temperature Chart

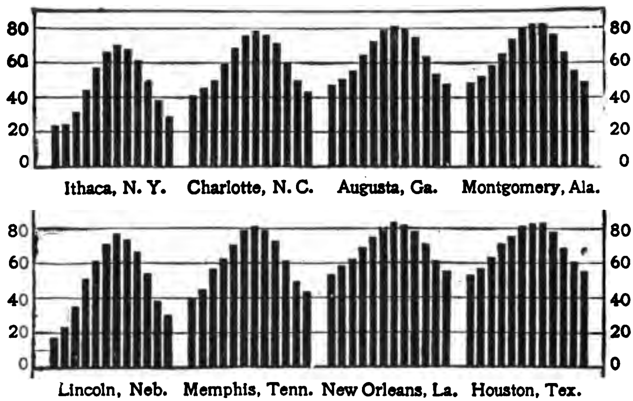


Chart showing temperature in different regions of the United States. Figures indicate temperature Fahrenheit per month. The months read from the left. Compare with chart below

Rainfall Chart

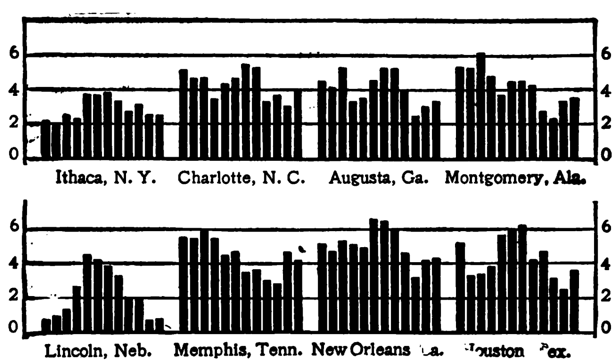


Chart showing rainfall in different regions of the United States. Figures indicate precipitation in inches per month. The months read from the left. Compare with chart above northerly sections of the cotton belt killing frosts occur as late as April 15 and as early as October 15, which is about the limit of successful cotton culture.

434. Rainfall.—While the cotton plant is extremely sensitive to temperature conditions, this alone is not sufficient for its economic production. During the growing period of the cotton plant the rainfall should be abundant and well distributed, while during the ripening period comparatively dry weather is desirable. Wet weather during picking is very injurious, especially when accompanied by high wind. Suitable conditions of rainfall and sunshine are more likely to occur inland than upon the coast. Upland cotton is therefore grown inland, while sugar cane and rice are more likely to be grown near the coast in tropical and semi-tropical countries.

435. Soils.—While under proper climatic conditions cotton can be raised upon all ordinary soils with a fair degree of success, the plant is greatly modified by the character of the soil upon which it is grown and upon the same soil by the amount of rainfall. As a rule sandy soils produce the smallest yields, but these can be depended upon for a crop under rather wide climatic conditions. Under the proper climatic conditions clay soils and silty clays produce the maximum crops, although under excessive rainfall the plant may run to wood, or as the planters say, to weed, with small production of lint. Uplands produce comparatively small plants which mature early, while bottom lands and rich black prairies produce much larger plants which mature later.

Cotton grown on some soils is more subject to disease and insect enemies than when grown on other soil types. As for most other crops, especially those which receive intercultural tillage, loam soils are considered safest, and are for other reasons preferred. Mellow, friable soils are more easily worked by light machinery. From a study of the different types of soils it is clear that clay loams and silt loams give much higher yields than sandy loams.

436. Soils for Sea Island Cotton.—"The best soils for this variety are light, fine-grained, sandy soils, containing from 4 to 8 per cent. of clay, from 4 to 6 per cent. of silt, and from 75 to 90 per cent. of fine sand. Soils of this character from James Island maintained during two growing seasons about 5 per cent. of moisture, and are very different from the best types of soils adapted to the upland cotton." [1]

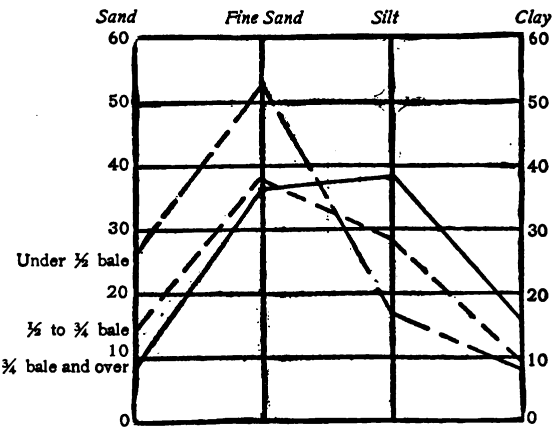


Diagram showing average composition of soils in Atlantic and Gulf coastal plains, as determined by mechanical analysis and their respective adaptability to cotton production

437. Deterioration of Cotton Lands.—Lands devoted to cotton continuously or in alternation with maize only readily deteriorate. The following table gives the per cent. of nitrogen, phosphoric acid, and potash found in the air-dry parts of the plant removed from the soil: [2]

Analysis	Lint	Seed
Nitrogen	0.24	3.07
Phosphoric acid, P_2O_5	0.06	1.02
Potash, K_2O	0.74	1.17

[1] U. S. Dept. Agr., Off. Expt. Sta. Bul. No. 33 (1896), p. 161.
[2] Tennessee Sta. Bul. Vol. XIV (1891); No. 5, p. 125.

The lint not only contains small percentages of nitrogen and phosphoric acid, but the weight of lint obtained per acre is small compared to the weight of most cultivated crops. The seed contains relatively high quantities of both substances, and there are rather more than two pounds of seed for each pound of lint. The seed, however, is not injured as a fertilizer by the extraction of the oil. If therefore all the plants except the lint and the oil is returned to the soil, the loss of these elements from the sale of the products is trifling.

The soil loses fertility by the oxidation of the vegetable matter in the soil during the summer months, and the washing away of the material thus made soluble during the winter months. The comparative bareness of the soil and the heavy rainfall favor erosion at all seasons of the year, causing the removal of quantities of surface soil. Formerly when land and labor were cheap, old cotton fields were abandoned when no longer productive, and new lands were brought under cultivation.

The cotton states have comparatively few domestic animals, and the climatic conditions do not favor the collection and preservation of manure. While manure is recognized to be of value it does not enter largely into the production of cotton. Since lands and labor have become dearer commercial fertilizers have entered largely into its production. More recently a greater diversity of crops, especially the introduction of the cowpea, has obtained. Such diversification is a factor of great importance in combating fungous diseases and insect enemies.

438. Rotation.—The two main soil problems connected with the growing of cotton are the preventing of the bodily removal of the soil through erosion and the securing such a rotation of crops as will restore the organic matter to soils depleted by long-continued clean cultivation in one crop.[1]

Notwithstanding that a well-ordered system of rotation of crops

[1] Report of the Secretary of Agriculture; in U. S. Dept. Agr. Yearbook 1905, p. 69.

has been demonstrated to be of great value, the continuous culture of cotton year after year on the same land has been and still is in large measure the common practise. (329) The following rotation is the one best suited to the largest number of cases under existing economic conditions: first year, maize with peas between the rows to be harvested for seed; second year, wheat or oats followed by cowpeas for hay after the cereal crop has been removed; third year, cotton. If more cotton is essential, cotton follows cotton, making a four-year rotation. If more maize is wanted, land may be planted to the crop two years in succession instead of two years in cotton.

After many years' experience the Georgia Station asserts that the increased production of the station farm is due more to the adoption and maintenance of a regular system of rotation than to any other practise, and that the recurring crop of cowpeas following the small grain is the most valuable and efficient detail of the rotation system adopted.

The objection to the rotation above mentioned is that it leaves the land bare during the winter after the cotton. The South Carolina Station recommends early varieties of cotton so that the crop may be gathered in time for fall plowing the cotton field, and the sowing of winter grain. The protection of the soil by the grain through the winter and early spring this station believes is alone of sufficient benefit to justify the practise of sowing grain on cotton land without taking into account the benefit of fall plowing and the value of the grain crop.[1]

The practical difficulties of a grain crop at this point in the rotation will probably prevent its extended use. Cover crops, however, of rye, oats, winter vetch, crimson clover or bur clover may be sown in the fall to be plowed under not later than February first. A farmer is reported to have increased the capacity of his Piedmont soil from one-third of a bale to two bales per acre by growing bur clover on the land each winter, the land

[1] South Carolina Sta. Bul. No. 120 (1906), p. 8.

being continuously kept in cotton. Since the bur clover reseeds itself each year, there has been no expense except for the original cost of the seed.[1]

439. INFLUENCE OF COMMERCIAL FERTILIZERS.—"Since the close of the Civil War to the present time practically all of the cotton cultivated in the United States, with the exception of comparatively small quantities grown on the alluvial soils of great river bottoms and occasional areas of newly-cleared land, has been fertilized with concentrated manures. Probably upon no other crop to which they have been applied have these manures exercised so great an influence as upon cotton. Not only were profitable crops made with them upon lands which without them it would not have paid to cultivate, and an immense area of worn-out land thus redeemed to culture, but the stimulant effect of the manure so shortened the period of growth and maturity of the plant that the climatic limit of culture was extended. Cotton soon came to be grown abundantly over large regions where, previous to the introduction of such manures, killing frosts intervened before the maturity and fruitage of the plant. The enormous increase in the cotton production of the United States since 1860 is undoubtedly to be credited chiefly, if not exclusively, to the use of concentrated manures." [2]

440. Carriers of Fertilizing Ingredients.—Kainit is the most common form for supplying potash to cotton. When it can be purchased as cheaply compared with the potash contained, it is considered rather more desirable than the refined muriate of potash, since the larger bulk and mechanical condition permit its more even distribution by the fertilizer drill.

Most of the experiment stations in the cotton states have compared nitrate of soda with cotton-seed meal as a carrier of nitrogen for cotton and find that they are substantially equal pound for pound of nitrogen contained therein under the conditions which they are ordinarily used. Since the cotton-seed meal furnishes the nitrogen at less cost, it is generally recommended and used. The Georgia Station, however, recommends whether cotton-seed meal or other fertilizers are used that 20 to 30 pounds of nitrate of soda per acre be used when seed is planted. Soluble and reverted forms of phosphoric acid seem to have given better results than

[1] U. S. Dept. Agr. Yearbook 1905, p. 202.

[2] U. S. Dept. Agr., Off. Expt. Sta. Bul. No. 33 (1896), p. 172.

the phosphorus occurring in rock phosphates. The acid phosphates are, therefore, generally recommended.

"While a few of the earlier tests made at Auburn were thought at the time to indicate the possibility of the economical substitution of the cheaper raw phosphate for the most costly acidulated material, our hundred or more experiments bearing on this question, taken as a whole, declare emphatically that under ordinary conditions and present prices it is more profitable to fertilize cotton with acidulated than with raw phosphate. When the latter is employed at all it is best to use in connection with it some form of organic nitrogenous material as stable manure, cotton seed, or even cotton seed meal."[1]

These experiments, however, have not taken into account the residual effect of the rock phosphate in a well ordered system of rotation.

441. Composting.—It is a common practise to mix, say, four parts of horse manure with one part each by weight of cotton seed and acid phosphate and allow them to ferment for four to ten weeks. To this mixture there may be added coarse litter of any sort, such as oak leaves, pine needles. Among the things accomplished by this process is a product which can be distributed in the fertilizer distributer, and the fermentation destroys the germinating power of the seed.

The experiments of the Alabama and other stations do not indicate that the process of fermentation increases the yield of cotton compared to using the same ingredients fresh, and applied early enough to prevent the cotton seed from germinating, unless it be in making available the coarse litter which may be employed. The chief consideration, therefore, in determining the desirability of composting fine stable manure, cotton seed and acid phosphate is convenience and cost of labor. Where manure is available it is considered desirable to mix with the commercial fertilizers and apply in the furrow rather than to apply broadcast. When desired for immediate use it may be necessary to screen the manure in order to remove the coarse litter, which may be done with an ordinary sand screen.

[1] Alabama Sta. Bul. No. 107 (1899), pp. 251, 252.

442. Kinds and Quantities of Commercial Fertilizers.—The Texas Station recommends 100 to 150 pounds of cotton-seed meal and 100 to 200 pounds of 14 per cent. acid phosphate. This station believes soils in Texas do not require potash.[1] The Georgia Station, as the result of fourteen years' experiments, recommends for cotton, on old worn uplands, a fertilizer containing nitrogen, available phosphoric acid and potash in the ration of 3:10:3. This ratio, but not these percentages, may be obtained by mixing 1,000 pounds of 14 per cent. acid phosphate; 700 pounds of cotton-seed meal containing 7 per cent. nitrogen, 2.5 per cent. phosphoric acid and 1.5 per cent. of potash, and 75 pounds of muriate potash.[2] From 350 to 700 pounds of this mixture are recommended to be bedded on two weeks before planting with 20 to 30 pounds of nitrate of soda applied in the furrow when seeds are planted.

When a well-ordered rotation is practised, each crop being liberally and judiciously fertilized, each succeeding cotton crop will require a somewhat less relative quantity of nitrogenous fertilizers. On well improved soils, on comparatively new soils, or on bottom lands the cotton seed may be reduced from one-third to one-half.[3]

For sandy soils the Alabama Station recommends the same mixture in amounts varying from 280 to 420 pounds per acre; for clay soils it is advised to omit the potash and apply from 240 to 320 pounds per acre of the cotton-seed meal and acid phosphate mixture, while for any well drained soils on which cotton is known to be liable to black rust it is advised to reduce the phosphate and increase the potash by applying the following mixture: cotton-seed meal, 120 to 160 pounds; acid phosphate, 80 to 120 pounds; and kainit, 80 to 120 pounds per acre. The lime soils of the central prairie region of Alabama usually

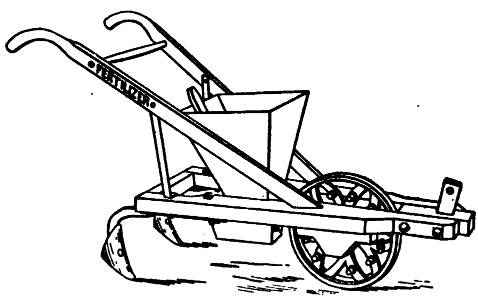
[1] Texas Sta. Bul. No. 75 (1904), p. 18.

[2] About 2.5 pounds of crushed cotton seed are equivalent as a fertilizer to one pound of cotton-seed meal.

[3] Georgia Sta. Bul. No. 70 (1905), p. 88.

fail to make profitable use of commercial fertilizers. For these soils drainage and the growing of leguminous crops are especially recommended.[1]

443. Methods of Applying Commercial Fertilizers.—Commercial fertilizers may be applied in the furrow at the time of planting the seed, or they may be bedded on some time, say two weeks, in advance of planting. It is best not to place the fertilizer in direct contact with the seed, especially if considerable quantities of potash or nitrogen salts are used. The fertilizer may be distributed by hand with fertilizer distributer or with the combined cotton seed planter and fertilizer drill. When large quantities of fertilizer are used a scooter plow may be run in the furrow to mix the fertilizer with the soil before "bedding on." When distributed by hand, the Texas Station recommends the tin bugle, to prevent the wind from interfering.



Common form of fertilizer distributer used by cotton planter

"This device is made of tin. It is three feet long, and has a diameter of two inches. The top is funnel-shaped, and may be any convenient size to receive the fertilizer. To one side of the top a handle is soldered. The man distributing the fertilizer carries the bugle in his left hand with the lower end of the bugle in the furrow and the funnel directly under the mouth of a sack of fertilizer carried in the right arm. The fertilizer is run into the funnel in a constant stream, the right hand acting as a check valve to control the passage of the fertilizer from the sack. Uniformity and rapidity of distribution may be secured after a few hours' practise."[2] In some cases the bugle is carried by a rope slung over the shoulder and fastened to rings attached at suitable places on the tube.

When the nitrogen in the fertilizer was obtained from cotton-

[1] Alabama Sta. Bul. No. 107 (1899), p. 286

[2] Texas Sta. Bul. No. 75 (1904), p. 19.

seed meal the Georgia Station during three years obtained slightly greater yields of seed cotton by bedding on the fertilizer two weeks in advance of planting than by applying it with the seed. The practise is to open the center where the row of cotton is to be with a double mold board plow, locally called a "middle buster." In this furrow the fertilizer is distributed, after which the ridges or beds are formed. Rather less yields were obtained by applying half the fertilizers two months after planting, when the nitrogen was derived from cotton-seed meal, and rather more when nitrogen was derived from nitrate of soda.[1]

The Alabama Station has not found any greater yields from fractional applications of fertilizers, but when the supply of nitrogenous fertilizers was inadequate at planting, nitrate of soda applied as late as the middle of July, and cotton-seed meal, applied in the latter part of June, have produced favorable results.

444. Collateral Reading.—H. C. White: The Manuring of Cotton. In U. S. Dept. Agr., Office of Experiment Stations Bul. No. 33 (1896), pp. 169-195.

[1] Georgia Sta. Bul. No. 70 (1905), p. 77.

XX

FIBER CROPS

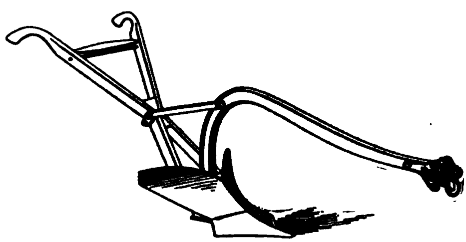
COTTON

I. *Cultural Methods*

445. Seasons of Cultural Operations.—The time during which the several cultural operations connected with the raising of cotton occur will depend somewhat upon the region. The cotton belt is generally recognized to have somewhat marked differences depending on whether the northern, middle or southern section is considered. While these three sections cannot be divided along parallels of latitude on account of differences of topography and proximity to seacoast, yet, in general, the section north of the thirty-fourth parallel may be looked upon as the northern section, while the section south of the thirty-first parallel may be considered to be in the southern section. The statements which follow will be for the middle section. South of this section the season is lengthened and north of it of course shortened.

The planter begins to prepare his land for cotton in February and March, and plants the seed in April, more rarely in May. During May, June, and July the crop is cultivated, the "chopping out" season usually being in June, but extending sometimes into July. The plant begins to flower in June, and its bolls mature and open 60 to 90 days later. The plants continue to bloom until September, and thus the picking season ranges from August until November. At the Georgia Station, during ten years the picking ranged from September 2 to October 3.

446. Preparing the Seed-bed.—The land having been plowed with an ordinary mold board or turn plow, the field is made up into alternate beds and middles or into "back" furrows and "dead" furrows. The row of cotton is to be planted upon the back furrow while the dead furrow facilitates drainage. On hilly land these beds follow the contour lines in order to prevent erosion. The custom varies somewhat with the need for drainage and other conditions, but in general the bed when finished is about six inches above the general level of the land, while the middle or center furrow is about six inches below the general level, making the middle furrow about twelve inches below the cotton row. There is considerable difference of opinion as to the necessity for this process of bedding, but there is practically no experimental evidence as to when it is desirable and when it may be omitted. Where cotton follows cotton, and where the soil is sandy, the land is usually not plowed before the beds are formed. In this case the bed is formed on the center furrow of the preceding year. In some cases the cotton plants are gathered and burned, and in other cases the stalk cutter is used, after which they may be plowed under without interfering with the subsequent cultivation. (C. A. 296)


The "Middle Buster"

The method of preparing the bed is somewhat as follows: The place where the cotton row is to be is opened by means of a scooter, which is merely a flat shovel four to five inches wide, and about twelve inches long, or by means of a middle "buster," which is a double mold board plow. The fertilizer is then placed in this furrow and the land turned back over the fertilizer by means of a small plow which turns a furrow seven to eight inches wide. Immediately afterward or usually a couple of weeks later, two or more furrow slices are thrown upon the previous ones, and the plowing continued until the middles are plowed out.

Whether it is good practise to permit an interval of some weeks to elapse between these operations is a matter of doubt. The practise of the Alabama Station is to complete the beds as soon as the fertilizers are applied. Doubtless on sandy soils it is desirable to have it completed some time before planting, in order that the seed-bed may be compact, while on clay soils, if much time intervened between the final preparation of the seed-bed and planting, the soil would become too compact.

Sub-soiling has been tried at several stations without material results and the practise is not advised. Breaking the soil six to eight inches, and giving this layer thorough preparation, is considered better than deeper plowing, with less preparation. The results of experiments on the preparation of the seed-bed vary greatly, and generally are inconclusive.

The furrows are sometimes opened in the fall. While this plan did not increase the yield of cotton, the Georgia Station believes that this method of opening deep furrows in the fall of the year may be expedient in practise as a means of preventing winter washing and the leaching of the soil on hillside farms.[1] The fall preparation of the soil for cotton is seldom practised, and as ordinarily performed would increase erosion. In level sections, as in parts of Texas, fall plowing is sometimes successfully practised.

447. **Kind of Seed.**—There is reason to believe that the larger seeds of any given variety will usually give the more vigorous start to the plant, and are to be preferred. Experiments in using heavy seeds as compared to light seeds indicate that the yield of seed cotton may be materially increased by planting only

[1] Georgia Sta. Bul. No. 70 (1905), p. 80.

heavy seeds. It has been suggested that it is desirable to plant old seed, on the theory that in old seeds the poorer ones fail to germinate, and by this process the seeds capable of producing the best plants will be selected. The Alabama Station, however, found that there was no difference in the yield of cotton due to the age of seed, when the same number of plants were grown per acre. The seed used for planting should be selected as heretofore described. (426)

The mixing of the seed of an early and of a medium variety has been recommended on the theory that it distributes the time of most vigorous growth, and therefore the demand upon soil over a longer period of time. This method seems to produce somewhat higher yields where both varieties are equally productive when planted separately, but if one variety was much less productive than the other the yield would be less than if the more productive one only had been planted.[1]

In order to carry on this practise it will be necessary to purchase seed from someone who grows seed pure, or else maintain a field of each pure for the purpose of selecting seed in addition to the field containing the mixed crop. The practise of maintaining fields of both varieties for the producing of seed for planting is desirable in order that the planter may know that the yields of both varieties are substantially equal.

448. Quantity of Seed.—The custom in the past has been to plant an enormous amount of seed, generally from one to three bushels per acre. Since a bushel may contain from 100,000 to 200,000 seeds, the number of seeds might vary from 100,000 to 600,000 per acre, while the number of plants finally left to bear fruit do not ordinarily exceed 12,000, and frequently less. The excess of seed forms a valuable fertilizer. With the better care in the selection of seed and the greater demand for the surplus seed, the practise is gradually obtaining to plant

[1] Georgia Sta. Bul. No. 63 (1903), p. 112.

less and better seed, sell the surplus seed to the cotton mills and use cotton-seed meal as a fertilizer.

The seed is planted by means of a one-horse cotton drill, or more rarely by means of the two-horse maize planter adjusted for cotton. (C. A. 305) Experiments are also being conducted by the United States Bureau of Plant Industry and others of rolling the cotton seed in a mixture of gypsum and flour to paste the fuzz to the seed in order that the seed may be planted in hills with an ordinary maize planter. It is considered a good practise, especially on sandy, friable soils, to compact the furrow above the seed by means of a heavy roller attached to the drill or otherwise.


Improved cotton drill with fertilizer attachment

449. Distance.—Experiments seem clearly to prove that cotton plants should be thinned to one in a place. The width of rows may vary from 2.5 to 5 feet, depending on the variety, the soil and the latitude. While the expense would be less for planting and cultivation with larger widths of rows, making less rows to plant, hoe, and cultivate, yet experiments indicate that the best yields are obtained with rows relatively narrow and the plants wider apart in the row, so as to make them more equidistant.

The results of the Georgia and the Alabama stations indicate that for land capable of yielding 0.75 to 1.5 bales of cotton per acre the rows should be 3.5 to 4 feet wide and the plants 12 to 18 inches apart in the drills, the narrow rows and closer spacing for the less productive soil, more northern sections and smaller growing varieties. For exceptional soils producing large cotton plants requiring more than ten square feet each, 4, 4.5 and even 5 feet, with a space of not more than three feet in the row, are recommended.[1]

With cotton, as with the cereals, the experiments indicate that the plant has great power of adjustment, the total yield of cotton per acre being often but slightly different when two and even three times the number of plants are raised per acre, the yield per plant being thus greatly modified on account of the thickness of planting. The width apart of the cotton is perhaps largely influenced by the fact that the chopping hoe is seven inches wide and two strokes with the hoe would leave a space of 12 to 14 inches between plants.

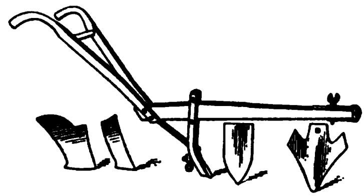
450. Cultivation.—Since the season of growth is somewhat longer and the cotton is always planted in drills, the amount of inter-cultural tillage is somewhat greater than with maize. It is customary to hoe one to three times, including chopping out, which is thinning the plants with a hoe to one or more plants to a place. At the same time the space between the rows is cultivated three to six times. A general rule is about once in ten days until the limbs hide the ground.

Usually no cultivation is given after cotton is planted until the plants are four to six inches high, which will be two to four weeks after planting, according to weather, soil conditions, and seed. The rows are then "barred off," which consists of throwing a small furrow away from the row with a one-horse turning plow or with a scooter plow. This leaves the plants on a narrow ridge. The cotton is then chopped out, after which the rows are "four furrowed," which consists in going twice around each row and throwing the earth toward the plants.

The more rapidly these operations follow each other the better, especially on soils likely to suffer from drought. After this the soil is best stirred with some form of surface cultivating tool, which may vary from the single heel scrape, ranging from

[1] Alabama Sta. Bul. No. 107 (1899), p. 223; Georgia Sta. Bul. No. 66 (1903), p. 125.

eighteen to thirty inches in width, and attached to a Georgia stock, to the cultivator with five comparatively small shovels. In any case the cultivation should not go deeper than is necessary for effective eradication of the weeds. In Texas, the cultural methods are not unlike those for maize where listing is practised. (C. A. 301)



Georgia stock with different types of shovels used in cultivating cotton

In Alabama a single deep cultivation at the second cultivation, all others being shallow, decreased the yield of seed cotton 85 pounds on prairie soil and 105 pounds on sandy soil. There appears to be no advantage in late cultivation unless made necessary by the growth of weeds. It is possible that late cultivation may be in some cases injurious by inducing increased growth of plant, or as the planters say, weed, and a corresponding decrease in fruiting.

451. Topping.—Sometimes the extreme top of the cotton plant is removed late in the summer, with the idea of checking the growth of the plants and inducing a greater development of bolls. Tests at several stations fail to show any advantage in this operation.

452. Picking.—Thus far cotton is picked almost exclusively by hand, although several machines have been invented and tried for this purpose. One of the several difficulties involved in producing a successful picking machine is the fact that the successive ripening of the bolls necessitates several pickings, and the passage of a machine over the fields injures the plants more or less extensively.

Cotton is picked by men, women and children, payment usually being made by the pound, ordinarily forty cents per hundred pounds of seed cotton, but may vary from thirty-five to sixty cents, and in some instances to one dollar per hundredweight. Since it takes about 1,500 pounds of seed cotton to each bale of 500 pounds, the cost of picking per bale is about six dollars. Two large items of expense in cotton culture are the picking and the chopping out, for both of which it is difficult to substitute machinery for hand labor.

The number of pickings will vary somewhat with the conditions, but perhaps four pickings are the most common number. The first picking usually occurs in the latter part of August and the last picking in the fore part of November. The largest yield and best quality of lint are obtained at the second picking, and the least at the fourth picking. In general, about half the yield of seed cotton is obtained at the second picking.

II. *Insects*

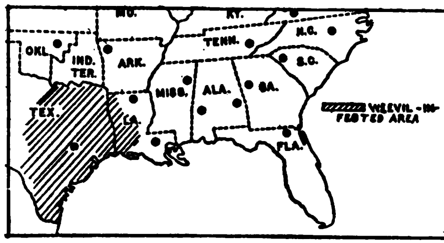
453. Insects.—There have been enumerated 465 species of insects which feed upon the cotton plant.[1] Of these the following are the most destructive:

1. The Mexican cotton-boll weevil (*Anthonomus grandis* Boh.).
2. The cotton bollworm (*Heliothis armiger* Hübn.).
3. The cotton worm or cotton caterpillar (*Aletia argillacea* Hübn.).
4. Cutworms (*Noctuidae*).

The Mexican cotton-boll weevil and the cotton worm are not known to feed upon any other plant than cotton. The cotton bollworm is the same species as the corn ear worm which attacks maize, tomatoes and many other crops. (C. A. 335) In the south, where it is about five brooded, the first three broods usually feed upon maize and the last two upon cotton. The Mexican cotton-boll weevil is a beetle, the others are moths. All are injurious in the larval state.

[1] L. O. Howard: Insects Affecting the Cotton Plant: Farmers' Bul. No. 47, p. 31.

As in the case of cereal crops, the most practicable method of combating in a large way insects injurious to cotton are a rotation of crops, thorough cultivation and general cleanliness of surroundings, which prevents the successful hibernation of the insects and decreases their opportunity for getting sustenance from volunteer plants. Cutworms are sometimes destructive by cutting off the young cotton plants. Trapping with poisoned green vegetation such as grass or cabbage placed here and there through the field has been found effective. (C. A. 329)



Map showing the distribution of the cotton-boll weevil up to 1905

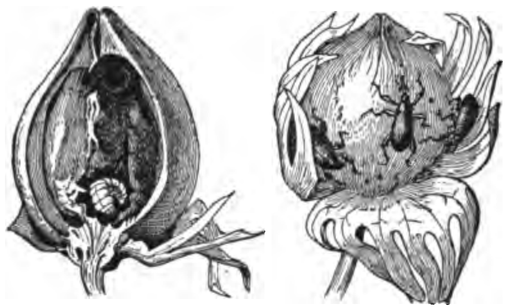
454. The Mexican Cotton-boll Weevil has gradually been spreading northward throughout Texas until at the present time it has spread over much of the cotton belt of Texas. The adult is a small grayish weevil less than a quarter of an inch in length while the larva which does the damage is nearly when full grown of equal length. The insects pass the winter in the adult state. In the spring they lay their eggs upon the buds, and later upon the bolls of the cotton plant, into which the larvae upon hatching bore and feed. It is a rule that buds which are attacked drop off while the bolls do not. In either case the injury is complete. There are a number of generations in a season, about two weeks being required for development from egg to adult, hence the injury is greatest in the latter part of the season and upon the later maturing plants. It is estimated that the progeny of a single pair in a season may amount to 134 million individuals.[1]

The method of combating this pest consists in reducing the number of insects in the fall by the early destruction of the plants, and in hastening the maturity of the plant by all available means, such as early planting, using early varieties or northern grown seed, use of fertilizers, thorough cultivation and proper spacing of plants. The plants should be plowed up in the fall as early as the crop will permit, and burned. In some cases pasturing with cattle may be effective. Each season's infection is more or less local since the adults do not travel rapidly, hence the measures above proposed are of value even though neighboring planters do not practise them. While care

[1] U. S. Dept. Agr. Yearbook 1903, p. 205.

should be taken to prevent the introduction of this pest into non-infected districts by means of seeds, hulls and other cotton products, yet the principal means of spreading seem to be the wind and the natural overflow from the infested area.

455. Cotton-boll Worm.—This insect, also known as the corn-ear worm, and as the tomato-fruit worm, feeds when young upon the leaves of the cotton, but, as it grows older, feeds upon the bolls and burrows into them, one insect



Cotton-boll weevil. Mature boll cut open at left, showing full grown larva; at right late fall boll showing how beetles hide between the boll and the squares (From photo by Howard)

sometimes destroying many buds, blossoms, and bolls. The insect hibernates in the pupa stage, and feeds upon many wild and cultivated plants, many of which it prefers to cotton. No thoroughly satisfactory method of combating this insect has been devised. The young larvae may be poisoned while they are feeding upon the leaves by the method described for the cotton worm, but this will not destroy the larvae after they have entered the bolls. Since they prefer other crops, and especially maize to cotton, the growing of five rows of maize between every twenty-five rows of cotton has been suggested. The rows of maize are planted at different times so as to bring on a succession of the silking period, and each row or group of rows is to be fed to live stock or otherwise destroyed just before or just after the eggs hatch. (C. A. 355)

456. Cotton Worm.—The larva of this insect resembles in appearance the cotton-boll worm, although generally of a lighter and more greenish color, and like it walks as a measuring worm. This insect, however, differs in habits in three important particulars: (1) so far as known it feeds upon no other plant; (2) it feeds principally upon the leaves of the plant, and never burrows into the bolls; (3) it hibernates in the adult or moth form, and cannot live over winter, except in the extreme southern portion of the cotton belt. If these worms appear north of this section, they occur by reinfection each season. Their spread can be greatly retarded by preventing the growth of any volunteer

cotton, while the worms can be effectively poisoned by dusting dry undiluted paris green upon the cotton. The cotton worm in recent years has not been especially destructive, and the method of poisoning is not so common as formerly.

"Make two sacks of heavy cloth, each about 10 inches long and 4 in diameter, open the whole length of one side and firmly sewed at the ends. We have found 8-ounce Osnaburg the best cloth for the purpose. Take a strip of oak or other strong wood, about 1.5 by 2 inches and 5 feet long, and bore a 1-inch hole 5 inches from the end. Tack one of the sacks to each end of the pole, fastening one of the edges of the opening to each of the narrow sides of the pole.

"The sacks can be filled by pouring the poison through a funnel inserted in the holes through the pole, and distributed by riding on horseback through the cotton rows, dusting two rows at a time. A little practise will enable one to do this work very evenly, and care must be taken not to allow the sacks to touch the leaves when wet or the poison will not pass through. When the sacks are freshly filled a very slight jarring will shake out a sufficient amount of the poison, but, when nearly empty, the pole should be frequently and sharply struck with a short stick, or spaces in the rows will be missed.

"When used in this way we have found it the best plan to use the poison without any admixture of flour, and if flour is to be added lighter cloth should be used in making the sacks. With a pole and sacks as described, one man and mule can poison from 15 to 20 acres per day."[1]

III. *Fungous Diseases*

457. Diseases.—The cotton plant is subject to a considerable number of diseases, some of which do widespread damage. While Texas has suffered greatly from insect attacks, fungous diseases seem thus far to have done their greatest damage in the states east of the Mississippi River, especially in the lower, more humid and sandy sections of these states. The following are the most important diseases arranged according to the part of the plant which they most obviously affect:[2]

THE ROOTS AND STEMS

1. Cotton wilt or frenching (*Neocosmospora vasinfecta* (Atk.) E. F. Smith).
2. Root knot or root galls (*Heterodera radicicola* (Greef.) Muell.).

[1] Mississippi Sta. Bul. No. 12 (1890), pp. 2, 3.

[2] F. S. Earle: Diseases of Cotton; in Alabama Sta. Bul. No. 107 (1899), p. 289.

3. Sore shin or damping off (*Rhizoctonia*).
4. Anthracnose[1] (*Colletotrichum gossypii* South.).
5. Root rot (*Ozonium* Sp.).

LEAVES

6. Rust, black rust or mosaic disease (*Macrosporium nigricantium* Atk.).
7. Red rust (*Tetranychus telarius*).
8. Leaf blight (*Cercospora gossypina* Cke.).
9. Cotton mildew (*Ramularia areola* Atk.).

458. ROOT KNOT is due to the same nematode worm that causes the root knot on cowpeas. (319) Red rust is due to a minute mite resembling the so-called red spider of greenhouses, while the other diseases above mentioned are due to mycelium-bearing fungi. In addition to these diseases there are the angular leaf spot, and the cotton-boll rot, the causes for which have not been determined, although probably bacterial. The shedding of bolls is also believed to be due to causes other than insect attacks. The most destructive diseases are the cotton wilt, root knot, black rust, and anthracnose. Sore shin or damping off destroys many plants, but owing to the habit of heavy seeding and subsequent thinning it does not ordinarily produce serious loss. No specific remedies have been found for any of these diseases.

459. COTTON WILT.—"The wilt is very distinct from any other disease of cotton, so that there need be no difficulty in its identification. It usually makes its first appearance in the spring about the last of May, when the plants are 6 to 8 inches high. It appears in well-defined areas, which enlarge if cotton is planted on the same land again. The first outward indication of its presence is a dwarfed growth and unhealthy appearance of the plants. The leaves turn yellow between the veins, their margins shrivel up, and some plants wilt and die at once. In other plants the progress of the disease is often slow, and many of them live the entire summer and die late in the season. On cutting across the stem of a diseased plant, the woody part will be found to be stained brown wherever the disease is present. In the absence of microscopic examinations, this brown discoloration of the internal tissue is the best ocular evidence of the presence of the wilt disease.

"Plants may partially recover from a severe attack of the wilt disease by the development of strong lateral branches near the ground. Such plants may be distinguished by their dwarfed and bushy appearance, and by the tendency of their branches to lie prostrate on the ground."[2]

The fungus does its damage by entering the smaller roots, and subsequently by its growth, filling up the water ducts with its mycelium, and thus cutting off the supply of plant food. The wilt disease of okra is supposed to be due to the same fungus, but that of cowpea is supposed to be slightly different. The infection is known to remain in the soil for four years, and probably longer, hence rotation of crops is of little avail after a field has become

[1] Also seriously attacks bolls.

[2] U. S. Dept. Agr., Div. Veg. Phys. and Path. Bul. No. 27 (1900), p. 6.

infested. The most effective method of combating is believed to be the breeding of resistant varieties. This is done by saving seed from the few plants which have survived a serious attack of the disease. These seeds are again planted in badly infested soil. By planting and selecting for several years varieties of sea island and upland cotton have been produced by the Bureau of Plant Industry which show a high degree of immunity to the disease.[1]

460. Black Rust.—The attack of the fungus causes the premature falling of the leaves, thus preventing the proper maturity of the plant. Losses may vary from 5 to 50 per cent., and being widely distributed the losses are very heavy. "It may be safely asserted that this disease cannot attack a cotton plant that is in full vigorous growth, but that a sudden checking of growth and lowering of vitality from any cause will render it liable to serious injury if the weather conditions favor the growth of these fungi."[2] The application of potash salts has been found in some cases to have a marked effect in enabling the plant to resist rust. (442)

461. Anthracnose.—This disease attacks the plant in all stages of growth. It produces death to the young seedling much as in the case of anthracnose of field beans. (270) It causes the bark of the stems to turn to a uniform reddish-brown, and to die. The leaves turn yellow and drop off. It is most conspicuously injurious to the bolls, which, when approaching maturity, may lose their green color and assume especially on the side exposed to the sun a dull red or bronze color. Under favorable conditions for the fungus the characteristic ulcers may appear, but in many cases neither stems nor bolls show them. Affected bolls may open normally and without material damage, but usually they open prematurely, exposing the immature lint which decays. The disease is not usually distinguished from rust, and is not usually recognized, but it causes in the aggregate considerable damage. The remedies suggested are burning of refuse, planting seed from unaffected plants or the treatment of the seed with a fungicide. If such seed were planted on land in affected cotton the previous year, the treatment would probably be of little value.

462. Collateral Reading.—C. W. Burkett and C. H. Poe: Cotton, pp. 153-164. New York: Doubleday, Page & Co., 1906.

J. F. Duggar: Preparation and Cultivation of the Soil for Cotton. In Alabama Sta. Bul. No. 107 (1899), pp. 215-224.

[1] U. S. Dept. Agr. Yearbook 1902, p. 383.

[2] Alabama Sta. Bul. No. 107 (1899), p. 302.

XXI

FIBER CROPS

COTTON

Production and Marketing

463. Cotton Crop of the World.—The following table shows the number of bales of lint produced by continents in 1904:

Continents	Bales[1]
North America	13,565,992
Asia	4,752,015
Africa	1,346,126
South America	216,204
Europe	17,125
Oceania	137
Total	19,897,599

Almost all the cotton produced in Africa comes from Egypt, most of that produced in Asia from British India and southern China, although a not inconsiderable amount is produced in Russian central Asia; while ten states of the United States produce nearly all of the cotton of North America, although Mexico also produces some cotton. Brazil and Peru are the principal cotton producing countries of South America. The ten cotton states of the United States in the order of their acreage in 1905 were Texas, Georgia, Alabama, Mississippi, South Carolina, Arkansas, Louisiana, Oklahoma,[2] North Carolina, and Tennessee. Over three-fourths the acreage was in the first five named states.

464. Cotton in the United States.—The acreage in cotton in the United States is exceeded only by maize, hay, wheat and

[1] Bales of 500 pounds gross weight, or 478 pounds of lint net.

[2] Includes Indian Territory.

oats, and constitutes about one-twelfth the total area in all field and garden crops, pasture excepted. The maximum acreage for a single year was a little over thirty millions in 1904. According to the twelfth census the area in cotton and maize in the ten principal cotton states was about the same, maize being

Percentage of the improved farm land in cotton in 1899

slightly in the lead. These two crops constituted 81 per cent. of the area in all crops in the ten cotton states, pasture excepted.

The average annual production of cotton for the four crop years of 1902 to 1905 inclusive, compared with the four corresponding crop years of the previous decade has been, according to the estimates of the United States Department of Agriculture, as follows:

Cotton statistics	1892–95	1902–05
Area, acres	20,366,420	25,325,472
Yield, bales, 500 lbs. gross	7,828,132	11,123,776
Value, dollars	271,047,709	529,030,192
Yield per acre, lbs.	185	210
Price per pound, cents	7.3	9.9
Value per acre	$13.51	$20.79

These figures show an enormous development in the cotton industry in a decade, not so much in the area under cultivation as in the increased yield per acre and the increased price per pound, resulting in the total value of the crop in four recent years being nearly twice that of the corresponding years ten years earlier, while the value per acre increased over 50 per cent. The figures here given do not show by any means the value of the cotton plant to the United States, since it forms the basis of a great manufacturing industry employing vast capital and many people.

465. Center of Cotton Production.—During the last half of the last century the center of cotton production has moved almost due westward about 200 miles. In 1850 the center of production was 28 miles southwest of Birmingham, Alabama, while fifty years later it was 34 miles north by west of Jackson, Mississippi (90° 18′ 12″ W. Long. and 32° 57′ 39″ N. Lat.). During this period maize moved westward 480 miles, so that at the present time the centers of production are on nearly the same meridian, although that of cotton is about 440 miles farther south.

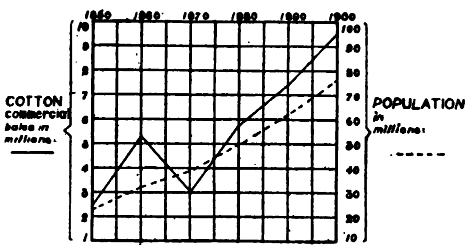


Diagram showing the increase in the production of cotton in the United States compared to population

466. Production per Population.—There were produced in 1899 about 59 pounds of lint cotton per inhabitant. In 1859 there were produced 78 pounds of lint cotton per inhabitant. This appears to be the highest production of cotton, in proportion to population, in the history of the country. Owing to the unsettled condition of the southern states during the decade which followed, the production of cotton fell enormously. Since

1870 there has been a gradual rise in the production of cotton, in proportion to population.

467. Exports of Cotton.—Beginning with 1875 the percentage which agricultural products formed of the total domestic exports has undergone a continuous decrease; in 1875 it was 77 per cent. while in 1905 it was 55 per cent. While the value of exports of agricultural products has become relatively less in recent years, the actual value of such exports has not decreased. In the ten years, 1896-1905, the exports of agriculture increased 50 per cent., those of the mines, the forests and the fisheries more than 100 per cent. each, while those of manufactures increased practically 200 per cent.[1] The export of raw cotton has increased more rapidly than that of all other agricultural products. On the other hand, the export of raw cotton has decreased in proportion to production. For the five years, 1891 to 1895 inclusive, 5,473,000 bales of domestic cotton were exported, which was 68 per cent. of the total production, while in the corresponding five years ten years later 7,097,000 bales were exported, being 55 per cent. of the total production. This indicates an enormous growth in the manufacture of cotton.

More than 95 per cent. of this trade, including sea island and upland cotton, went to Europe; 3.8 per cent. went to Japan and British North America in the proportion of 3:2 respectively, while the remainder went chiefly to Mexico. Great Britain was the chief buyer, while other important countries were, respectively, Germany, France, Italy and Spain.[2]

The table on next page gives the exportation of raw cotton from the United States by customs districts for the year ending June 30, 1905.[3]

[1] Dept. Com. and Labor, The Foreign Commerce and Navigation of the United States, 1905, p. 17.

[2] Dept. Com. and Labor, Statistical Abstract of the United States, 1905, p. 392.

[3] Dept. Com. and Labor, The Foreign Commerce and Navigation of the United States, 1905, p. 779.

Districts	Bales	Pounds	Dollars
Atlantic ports	2,883,545	1,463,315,224	133,524,576
Gulf ports	4,999,796	2,602,715,603	222,690,144
Mexican border ports . .	37,807	19,570,868	1,992,648
Pacific ports	307,428	164,093,478	16,607,020
Northern border and lake ports	109,388	55,153,730	5,150,626

Sea island cotton, 42,721 bales, went out of Atlantic ports exclusively. More than 95 per cent. of the raw cotton exported from the United States in 1905 was shipped from twelve ports. For the five years 1901-05 five ports sent out more than 200,000 bales annually in the following descending rank: New Orleans, La.; Galveston, Tex.; Savannah, Ga.; New York, N. Y., and Wilmington, N. C. During the same period New Orleans and Galveston together contributed more than 47 per cent. of the total exportation, the former port being a trifle in the lead. Other important ports were, respectively, Brunswick, Ga.; Mobile, Ala.; Charleston, S. C., and Puget Sound, Wash.[1]

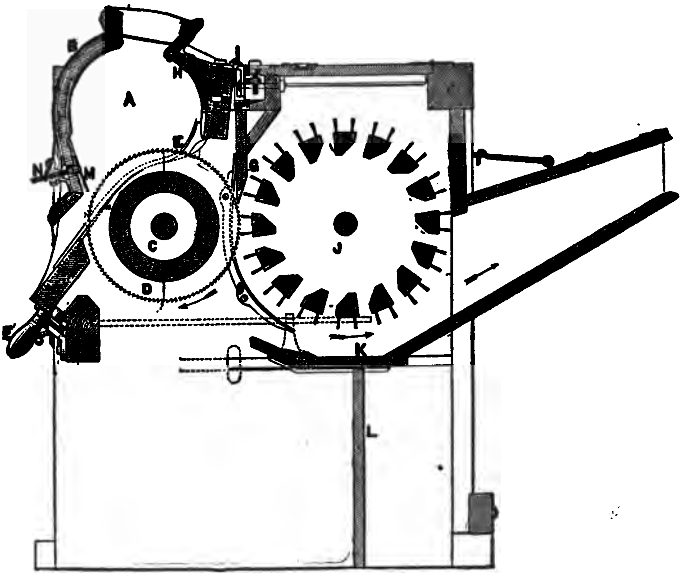
468. Imports of Cotton.—For the five years 1891 to 1895 inclusive, there were imported into the United States 340,557 bales of raw cotton, while in the corresponding five years ten years later 659,141 bales were imported.[2] Chief among the countries from which this trade comes are Asiatic Turkey and Egypt, these two countries together contributing more than 90 per cent. of the entire importation. The remaining importations come from Great Britain and Peru, the trade with other countries comprising a negligible quantity.[3] These importations came by way of Atlantic ports chiefly.

[1] Dept. Com. and Labor, Statistical Abstract of the United States, 1905, p. 388.

[2] Dept. Com. and Labor, Statistical Abstract of the United States, 1905, p. 440.

[3] Dept. Com. and Labor, The Foreign Commerce and Navigation of the United States, 1905, p. 195.

469. Gins.—There are two kinds of gins: roller gins and saw gins. The roller gin has been used in India under the name of churka since ancient times. Sea island cotton is ginned ex-



Diagrammatic section of saw gin

A—Grate-fall Head or End of Breast.
B—Seed-board.
C—Saw-cylinder.
D—Saw.
E—Grate.
F—Lever for raising Grate-fall.
G—Wind-board.
H—Adjustable Hollow.
I—Sliding Butt.
J—Patent Brush.
K—Sliding Mote-board.
L—Bottom Board.
M—Movable Iron Plate with Teeth, to regulate cleaning seed.
N—Screw to adjust the Iron Plate M.
O—Iron Brush Guard.

clusively on a roller gin. While the roller gin gives the best results for long staple upland cotton, yet the saw gin is usually used for this type of cotton on account of its greater capacity.

The invention of the saw gin as patented by Whitney and Holmes more than a century ago, has greatly affected the cotton industry. The improvement in gins since that time has been in perfecting mechanical details and the adoption of labor saving methods. The seed cotton is fed from a hopper into the breast where the revolving saws operate upon the seeds, removing the lint. When the lint is removed the seeds drop through an opening, while the lint is removed from the saws by means of a revolving cylinder studded with 25 to 30 rows of bristles. At the same time this cylinder causes a draft of air, which condenses the lint against a revolving and perforated cylinder whence it is removed in a continuous sheet and conveyed to the press.

470. **Bales.**—The standard square bale of cotton as it is first baled, or as it leaves the gin, is 54 inches long, 24 inches thick and 42 to 46 inches wide and has, therefore, a density of about 14 pounds per cubic foot. These bales, as they are sold by the planter, are shipped to the compress where they are re-pressed, the width being reduced to 20 inches so that the final bale is 54x24x20 inches, and has a density of about 30 pounds to the cubic foot. Numerous attempts have been made to make a bale at the gin of sufficient density for final shipment, and at the same time not injure the staple. The form of bale which has been most used for this purpose is the 250-pound cylindrical lap bale. The lap of lint as it comes from the gins is pressed around a rod under high pressure. This cylindrical bale is 40 inches long, and has a density of about 30 pounds per cubic foot.

471. **Presses.**—Ginnery presses for making the standard square bales may be divided into three kinds: screw presses, hydraulic presses, and direct steam presses. Screw presses may be run by mule, horse, water, steam, or other power, and when each plantation did its own pressing, this was the common form. In hydraulic presses the hydraulic pump forces the water or oil against the vertical ten-inch cylinder and plunger at a pressure of about 600 pounds per square inch, or about 47,000 pounds per bale.

In the steam presses the cylinder and piston are about 30 inches in diameter and the boiler pressure of the steam is from 70 to 100 pounds per square inch or from 50,000 to 70,000 pounds per bale. Compresses are simply specially powerful steam presses having cylinders from 80 to 90 inches in diameter, which are operated under about 100 pounds pressure, or from 500,000 to 600,000 pounds per bale.[1]

Wood frame hand and horse cotton press. Dotted line shows levers of horse press

472. Ginning.—Short staple upland cotton is ginned on a saw gin as invented by Whitney and Holmes, although subsequently much improved in mechanical details. Formerly each plantation ginned its own cotton and pressed it into bales by means of the wooden screw presses, but at present most of the cotton is ginned and pressed at the public ginnery.

A gin is usually rated by the number of its saws, 70 saws being the standard size and capable of ginning about a bale an hour. An ordinary public ginnery usually has four to six gins so arranged as to convey the cotton from the wagon through a twelve-inch pipe by suction, to feed the cotton simultaneously into all the gins, and to collect the ginned cotton as it leaves the different gins into a single condenser which delivers the lint in a continuous stream into the press. At the same time the seed is delivered by special conveyer, air-blast or suction,

[1] For detailed discussion of modern cotton gins and presses, see D. A. Tompkins: Cotton and Cotton Oil, Chapter VI.

to an elevated bin from which the owner may receive it in his wagon by gravity. Thus, in a few minutes from the time the cotton is unloaded, the owner may receive his seed and his baled cotton. During the whole process little or no hand labor is required. The improvement in the economy of labor in ginning and pressing cotton is analogous to that brought about by the steam thresher and the elevator system in cereal production.

The commercial value of cotton may be seriously affected by the process of ginning. Anything which tends to break the fibers will necessarily reduce the value for manufacturing purposes. Good ginning depends on the freedom of the seed cotton from foreign substances, as leaves and burs, on dryness of the crop, on the condition of the gin and the rate at which the gin is run, and on proper feeding of the seed cotton. The common rate of speed for the steam engine is about 500 revolutions per minute. A rate of 300 revolutions per minute will produce a lint of higher quality, but will greatly reduce the capacity of the gin. Newly sharpened saws or wet cotton may cause breaking of the fibers. Special gins, known as delinter gins, are made for removing the "fuzz" or linters from seed which is to be used for the production of cotton seed oil.

473. Marketing.—The seed cotton is ordinarily taken to the public gin in wagon holding about 1,500 pounds of seed cotton, or about a bale of lint. This is ginned and baled at once at a cost of about a dollar a bale, the planter receiving back the cotton baled, which he may sell at once to the cotton merchant or store in the warehouse, or return to the plantation until he is ready to dispose of it. When stored in the warehouse, there is a charge for storing, insurance and usually selling, amounting to one to two dollars per bale. After baling, cotton is frequently stored with little or no protection, often to its serious detriment.

All railway towns of moderate size or larger have cotton merchants who buy the cotton for cash upon inspection. The cotton is then shipped to larger shipping points where the bales are compressed for final shipment to manufacturer or exporter. The planter may receive his seed back with his baled lint, or may sell it to the ginner, who frequently acts as agent of cotton mill companies or buys seed upon his own account.

474. Commercial Grades.—In buying cotton, a sample is taken by hand from the surface of the bale, and the judgment as to the quality of the whole bale is made upon such sample. Ordinarily there is little opportunity to have the contents of the square bale designedly non-uniform, and if such should occur, the marks upon the bale permit the source of the cotton to be located.

There is no standard for grading cotton, nor are there any authorized agencies for grading cotton, it being done by men who have become expert, but who are usually unable to give any reason for their judgment. Under this system the grading at small centers is always made low enough to be sure to pass when it reaches the larger markets. The most important characters of cotton are the length, strength and uniformity of staple. As a matter of fact, however, cotton is graded largely upon cleanliness, color indicating its exposure to the weather and upon the feel, determined largely by pressing the sample in the palm of the hand.

Upland cotton is graded in America into seven principal grades, from highest to lowest as follows: fair, middling fair, good middling, middling, low middling, good ordinary, ordinary. It will be seen that the middling grade is intermediate between the highest and the lowest grade, which probably explains the use of the term, since it has no significance so far as the source of the cotton or the use to which it is to be put is concerned. The grades above mentioned are what are known as *full* grades. Between each of these grades there are usually three intermediate grades: thus between the full grades fair and middling fair there are the intermediate grades from highest to lowest as follows: barely fair, strictly middling fair, and fully middling fair.

The term, strictly, is used to signify a grade half way between the full grades, while the term, barely, signifies a grade intermediate between the next higher full grade and the half grade, and the term, fully, is used to apply to a grade intermediate between the half grade and the next lower full grade. The first of these intermediate grades is known as quarter grades. In ordinary market quotations, quarter grades and some half grades are not used. The markets usually recognize a difference between cotton from regions which are principally low lands and river bottoms and that coming from uplands. The former, known as gulf cotton, usually has slightly longer staple. The following table gives the grades quoted on the New York Cotton Exchange, and shows the range of prices due to difference in kinds and grades of cotton:[1]

Grades and Prices[2] of Cotton

Grades	Uplands	Gulf
Fair	12.10	12.35
Middling fair	11.96	12.21
Strictly good middling	11.52	11.77
Good middling	11.09	11.64
Middling	10.90	11.15
Strictly low middling	10.75	11.00
Low middling	10.52	10.77
Good ordinary	10.10	10.35

The middling grade is known as contract grade, since it is customary to base all contracts for cotton on this grade, although the cotton delivered may be of a different grade, the price being adjusted to the grade furnished.

475. Yield.—The yield of cotton for four recent years has

[1] The prices given are for July 31, 1906. American Wool and Cotton Reporter, Vol. XX, p. 991.

[2] Dollars per hundred weight.

been 210 pounds per acre as compared with 185 pounds a decade earlier. A yield of 1,500 pounds of seed cotton containing 500 pounds of lint, popularly spoken of as a bale of cotton, is considered a good yield.[1] Two bales of cotton are not unusual on certain types of soil. The yield of sea island cotton is less, from 100 to 300 pounds being considered fair to good yields.

476. Price.—Since the United States raises such a large proportion of the cotton of the world, and since there is no other fiber that will replace cotton for most purposes at anywhere near the same price per pound, any large fluctuation in yield which may easily occur on account of climatic conditions, fungous diseases or insect attacks, may profoundly affect the price of cotton. Thus during the past ten years the December price of middling upland cotton has ranged from 5.6 to 14.1 cents per pound, and the May price has varied from 6.1 to 13.9 cents per pound.

When short staple upland cotton is worth 9 cents a pound, long staple upland with one and a quarter inch staple may be worth 12 cents, and with one and a half inch staple may be worth 15 cents. The price of sea island cotton is quite variable, but in extreme cases may bring 70 cents a pound. In the past fifteen years the price received for seed by the planters has risen from ten dollars or less to fifteen or more dollars a ton. Thus when a grower sells a bale of cotton for forty-five dollars, he may receive from seven to eight dollars for his seed.

477. Collateral Reading.—Alfred B. Shepperson: Cotton Facts (Annual). New York: The Author, 15 William Street.

C. W. Burkett and C. H. Poe: Cotton, pp. 200-233. New York: Doubleday, Page & Co., 1906.

H. Thompson: From the Cotton Field to the Cotton Mill. New York: The Macmillan Co., 1906.

United States Department of Commerce and Labor, Bureau of the Census Bul. No. 40, 1906. Cotton Production, pp. 46 et seq.

Twelfth Census of the United States, VI (1900), Part II, pp. 405-419.

[1] A commercial bale of cotton is usually rated at 500 pounds gross—that is, including bagging and metal hoops, containing 478 pounds of lint.

XXII

FIBER CROPS

COTTON

Uses and History

478. Lint.—The cotton plant is in many respects the most important upon the globe. It furnishes the clothing of the larger portion of the inhabitants of the world. It is subject to more extended and varied use under the widest conditions of climate and civilization of any other fiber. It is the most important article of trade. It employs more capital and labor than any other single manufacturing industry.

The usual method of utilizing cotton is first to spin the lint into threads technically known as yarn. The fineness of the yarn is measured by the number of "counts" to the pound of lint cotton. A count is a "hank" of 840 yards of yarn. Thus sea island cotton usually produces yarn ranging from 120 to 320 counts per pound. In other words, one pound of sea island lint cotton produces from 120 to 300 hanks of 840 yards each.[1] Short staple upland yarn is woven into all sorts of fabrics, is used for mixing with wool, silk and flax, knit into hosiery or made into cordage of various sizes and descriptions. Long staple upland cotton is utilized largely for making sewing threads and fine lawns, while the finer threads for sewing and for laces and the finest cotton fabrics are made from sea island cotton.

[1] It is said that a pound of sea island cotton has produced as high as 2,000 counts.

The following table shows the number of counts usually obtained from a pound of lint of the several types of cotton:

Table Showing Number of Counts in Different Types of Cotton

Type	Number of counts
Short staple upland	30–60
Long staple upland	50–80
Peruvian	40–70
Egyptian	70–250
Sea island	100–400
Linters	8–10

479. **Manufactories.**—In 1901 there were in the United States 1,055 establishments for the manufacture of cotton exclusive of hosiery and knit goods. The valuation of the products, including custom work and repairing, of these manufactories at that date was in round numbers 339 million dollars. The average value of imports of cotton manufactures during 1901-05 was $47,122,800, as against average exports to the value of $31,333,375.[1]

Of spindles in operation September first, 1905, there were 23,850,000 as against 16,100,000 the same date in 1895. The average percentage of the commercial crop taken by United States mills has been for the years 1901-05 a trifle more than 36 per cent. The statistics of the factory supply, number of spindles and mill consumption of cotton by countries were as shown in table on page 378.[2]

In the United States the number of spindles in the northern states was 15,865,790, while in the southern states it was 8,211,734. The increase in the number of spindles in five years was 12 per cent. in the northern and 108 per cent. in the southern states.

[1] Dept. Com. and Labor, Statistical Abstract of the United States, 1905, pp. 441, 655, 656.

[2] Dept. Com. and Labor, Bureau Census Bul. No. 40 (1906), p. 56.

Table Showing World's Statistics of Cotton, 1904-05
Bales 500 Pounds Net

Country	Commercial crop for 1904 bales	Spindles number	Mill consumption bales
United States	13,084,575	24,077,524	4,278,980
Great Britain	....	48,400,000	3,600,000
Russia	554,000 [1]	7,000,000	1,285,000
Other Europe	....	27,988,546	5,003,900
India	2,712,000	5,250,000	1,590,000
Japan	....	1,387,846	875,000
Egypt	1,258,000	....	....
Other countries	833,000	3,422,822	760,000
Total	18,441,515	117,526,738	17,392,880

480. Seed.—The extravagant statement has been made that if the cotton plant produced no lint, it would still be worth growing on account of its seed. In recent years, however, cotton seed has risen to such a price on account of the increasing demand of the cotton-seed oil mills that it has become an important element in the cotton planter's profits. The seed as received by the oil mill is first re-ginned, by which a portion of the linters is removed. It is next hulled, since the hulls would, if not removed, absorb the oil. The meats are next cooked at 220° F. for 15 to 20 minutes to coagulate the albuminoids, to partially drive out the water and to melt the oil, and finally subjected to a pressure of 3,000 to 4,000 pounds per square inch. The crude oil is shipped in tank cars to the refinery, while the cake is dried, cooked, and then ground, when it is known as cotton-seed meal.

The amounts of the different products obtained will vary with the character and condition of seed, and the skill and per-

[1] Turkestan and Transcaucasia in Asia.

fection of the manufactory methods, but the separation is never absolutely perfect. (407) The uses which the seed serves may be shown in the following graphic manner, which gives standard results obtained at the cotton-seed oil mills:[1]

- Cotton seed 2,000 lbs.
  - Short lint or linters 35 lbs.
    - Batting
    - Carpets
    - Rope and twine
  - Hulls 865 lbs.
    - Cattle food
    - Fuel
    - Fertilizers
    - Paper stock
  - Meats 1,100 lbs.
    - Crude oil 300 lbs. or 40 gallons
      - Culinary uses
      - Lard compounds
      - Substitute for olive oil
      - Oleomargarine
      - Medicinal compounds
      - Soap stock
    - Cake meal 800 lbs.
      - Cattle food
      - Fertilizer

The seed is still used largely as fertilizer, either composted with manure and commercial fertilizers or otherwise, although less extensively than formerly. (440) The seed is rather sparingly used as cattle food.

481. Oil.—The cotton-seed oil industry has developed chiefly in the last quarter of a century, the greater progress being made in the last decade. In 1905 there were 715 cotton-seed products mills representing a capital of seventy-four million dollars.

[1] The Census Bureau gives the quantity of products per ton of cotton seed, as manufactured in the United States, in 1905, as follows: crude oil 300 lb., meal 813 lb., hulls 725 lb., linters 35 lb.; total 1,873 lb. The value of the products is given as follows: crude oil $9.37, meal $8.30, hulls $1.67, linters $1.38; total $20.72. The average cost of a ton of cotton seed to the manufacturer is given as $15.53.

The crude oil which is pressed from the meats of the cotton seed goes to the refinery where it is first filtered to remove foreign matter in suspension, and then treated with caustic soda, which unites with the free fatty acids. This product, called soap stock, is removed by settling, or more rarely by filter presses, and is used in the manufacture of soap. The resulting oil is known as summer yellow oil, which may constitute from 80 to 95 per cent. of the original crude oil.

Summer yellow is next mixed with fuller's earth and the agitated mass passed through a filter press, which removes the yellow color and leaves the oil nearly or quite the color of pure water, when it is known as summer white oil. Summer white oil is used for making lard compounds, in the manufacture of oleomargarine, as a substitute for olive oil, and directly as cotton-seed oil for various culinary purposes for which lard and other fats are used. It is also sold largely under the name of salad oil, although not all salad oil is cotton-seed oil. Although a perfectly desirable and healthful article of food, its use is unfortunately somewhat surreptitious. While much of the larger amount of cotton-seed oil in commerce is summer white oil; other kinds or qualities of oil are produced. Summer yellow oil is sometimes bleached to a white oil by the use of sulphuric acid, when it is known as miner's oil.

Winter oils are also produced from summer oils by reducing the temperature to about 30° F., when the stearin solidifies and is separated from the liquid olein by filtration under pressure at the temperature named. The stearin is sold to make lard compounds such as cottolene, while winter yellow oil is highly prized for cooking, because olein does not decompose on frying so readily, and hence does not produce the disagreeable odor noticeable with summer oils.[1] Winter white oil is used for the manufacture of medicinal compounds.

"Cottonseed-oil mills may be divided into two classes: (1) those of large capacity, erected at railway centers, and (2) small cooperative mills, built in

[1] Tompkins: Cotton and Cotton Oil, p. 359.

towns with scanty railway facilities and depending for seed upon local supply. Each class of mills has its advantages. The larger mill has more competition in securing its seed supply, but on the other hand, it can readily draw upon other localities. The expenses incident to operation and marketing of product are proportionally less than in the smaller establishment, and make it possible to employ expert operators. It can carry the processes of manufacture further, refining its oil, and conducting correlated industries.

"An advantage of the small operative mill is that the farmers, on account of stock holdings, furnish the seed supply at reasonable prices, and guarantee a ready market for the meal and hulls for fertilizing and feeding purposes. In this way freight charges are saved both on the seed and on the more bulky products, leaving only the oil and linters, which constitute about 17 per cent. of the weight of the products obtained from a ton of seed, to be shipped to remote markets.

"Possibly the most difficult problem in connection with the cottonseed products industry is the proper storing and preservation of the seed. The lint is almost waterproof, and is but little injured in passing from field to the factory. But not so with the seed, which is very easily injured, and reaches the mill in much worse condition relatively than the lint. In wet seasons this deterioration amounts to a large percentage of the value of the seed, and the products from such damaged seed must be sold for very inferior uses. The value of the oil especially depends upon the condition of the seed when it reaches the mill. Evidently the products manufactured from cottonseed would be more useful and more valuable if it were carefully graded and the good and bad seed kept separate. To accomplish this the cooperation of the grower, ginner, and miller is required. The present tendency to establish small cottonseed-oil mills with ginneries attached is a step in this direction, as the seed may be stored at the time it is removed from the lint." [1]

482. Cotton-seed Meal.—The weight of cotton-seed meal is about two-fifths that of the cotton seed as it goes to the cotton-seed mill. It is used in the United States as a fertilizer either as such or mixed in commercial fertilizer. It is used principally as a source of nitrogen, but also contains phosphoric acid and potash, the percentage of each in round numbers being 7, 2.5, and 1.5 per cent. respectively. Cotton-seed meal is extensively sold as cattle food, being largely exported to Great Britain and other countries. Mixed with wheat flour or maize meal, it has been baked into various forms of bread stuffs, when it is said to be palatable and wholesome. The ex-

[1] Dept. Com. and Labor, Bu. Census Bul. No. 40 (1906), pp. 68, 69.

port of cotton-seed cake and cotton-seed meal was in 1905, 626,000 tons valued at nearly fourteen million dollars.

Table Showing Composition of Cotton-seed Meal[1] and Hulls

Analysis	Cotton-seed meal			Cotton-seed hulls		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Water	5.3	18.5	8.5	7.3	16.7	11.4
Ash	1.7	10.6	7.0	1.7	4.4	2.7
Protein	23.3	52.9	43.3	2.8	5.4	4.2
Crude fiber	1.9	15.2	5.4	35.8	67.0	45.3
Nitrogen-free extract	9.2	38.7	22.3	12.4	41.2	34.2
Fat	2.2	20.7	13.5	0.8	5.4	2.2
Nitrogen	3.2	8.1	6.8	0.4	1.0	0.7
Phosphoric acid	1.3	4.6	2.9	0.1	0.6	0.3
Potash	0.9	3.3	1.8	0.4	1.3	1.0

Cotton-seed meal is highly prized as a source of easily digestible protein and fat for milch cows, and fattening cattle and sheep. Experience has shown that it is unsafe to feed to calves and to swine of any age, sickness and death resulting from causes not well understood.[2] When fed to milch cows, fattening cattle and sheep, it is desirable to begin gradually, and not to feed exclusively or excessively. A safe rule is to begin feeding not to exceed two pounds per day per 1,000 pounds live weight, and not to increase beyond six pounds per day. Fermented meal never should be used for feeding. Fresh meal has a bright yellow color and a nutty odor.

Cotton-seed meal is sometimes adulterated with finely ground cotton-seed hulls. The hulls are not injurious but decrease the

[1] Sometimes called decorticated cotton-seed meal to distinguish it from meal that is made without removing hulls. In most cotton growing countries, except the United States, it is customary to express the oil without previous removal of the hulls.

[2] Texas Sta. Bul. No. 55 (1899), p. 209.

feeding value. It is said that English feeders prefer cotton-seed meal made from seed in which the oil is expressed without removing the hull because of the mechanical action of the hulls, such meal being purchased at a less price per ton. When fed to milch cows, cotton-seed meal raises the melting point and decreases the volatile acids of the butter.

483. Hulls.—Under present conditions of manufacture, a ton of cotton seed produces 700 to 900 pounds of hulls. These are used for cattle feeding, when they are considered equal to rather poor hay. They are also burned under the boilers of oil mills and the ash, which is rich in potash, used as a tobacco fertilizer. The hulls are also sometimes used as a fertilizer, but are not considered especially valuable, except for their mechanical effect upon heavy clay soils.

484. Stalks.—The dry matter in stems, leaves, and burs required to grow 500 pounds of cotton will weigh from 2,500 to 3,000 pounds. By the time the cotton is picked the leaves, about 20 per cent. of the whole plant, have largely fallen together with some of the burs. In fenced fields cattle are sometimes allowed to browse during the winter. They eat the burs and smaller branches, leaving only the main stems. The cotton plant is not especially palatable to domestic animals, doubtless on account of the so-called resin cavities which play the part of a protective agency.

When the land is put into cotton again or into some other crop, the stalks are gathered and burned or, what is considered a better practise, they are cut up with a stalk cutter and plowed under. A good quality of fiber has been obtained from the bark. Five tons of stalk will produce one ton of bark, and one ton of bark will produce 1,500 pounds of fiber. A good quality of paper has also been made from the stalks. In neither of these particulars has the plant assumed any commercial importance.

485. History.—The general cultivation of cotton is not very ancient as compared to that of wheat. In a limited way it was cultivated in southeastern India in early times. The clothing of the ancient Egyptians was made of wool and flax. Alexander the Great is supposed to have brought the culture and use of cotton from India to the native Europeans. It was found in cultivation and use from Mexico and the West Indies to Brazil and Peru when America was discovered.

The cultivation of cotton was limited before the Revolutionary War. It is said that in 1784 eight bales of American cotton were confiscated in Liverpool on the plea that cotton did not grow in America. The saw cotton gin, as invented in 1792 and patented in 1793 by Eli Whitney, with improvements patented by Hogden Holmes in 1796, greatly decreased the labor of removing the lint from the seed. This unique invention and the excellent adaptation of southern United States to the growth of the cotton have been prime factors in making the culture and manufacture of cotton the world's greatest industry.

Practicums

486. Study of Cotton Plant in Field.—Students may be taken to the cotton field at any time during the picking season, preferably at the second picking. Materials needed are a tape measure and a small fine-toothed comb.

Distance apart of rows..........ft., ...in.

Distance apart of plants in row: average of 10 plants..........in.

Ground: level, ridged; weedy, clean; compact, mellow.

Plants: height..........ft., ...in.; width..........ft., ...in.

Stem: continuous, divided; branches, abundant, medium, scarce; largest branches at bottom or middle.

Branches: cylindrical, not cylindrical; boll-bearing, not; internodes or joints ....in.

Fruit branches: where do they occur? .... Length..........in. Range of number of bolls..........to..........

Leaves: number and depth of lobing.......... Are leaves opposite or alternate?.......... Are stipules present or absent?..........

Hairiness of stems, branches and leaves: strong, medium, slight, absent.

Bolls: no. on plant.........; no. open.........; average length.........; average circumference..........; round, ellipsoidal, oval, irregular; pointing upward, downward; length of pedicel.........in. Sketch a longitudinal and cross section of bolls.

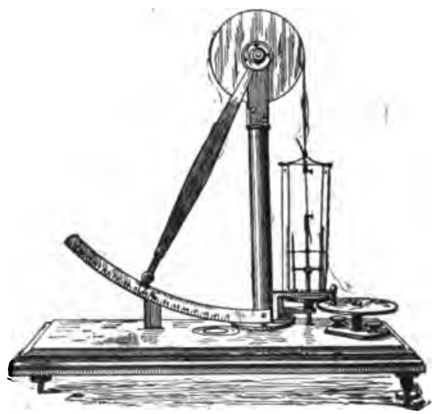
Burs: heavy not rolled, thin rolled; blunt pointed, sharp pointed; number of carpels..........

Locks: no. of seeds per lock..........; sketch arrangement; adherence to bolls, compact or flabby.

Seeds: fuzzy, naked; if fuzzy, white, green, brown; if naked, black, brown; large, small; length of 5 placed end to end..........in. Is the hilum at large or small end?..........; where does longest lint occur?..........

Lint: average length, ...in.; white, amber, brown; clean, dirty; strong, medium, weak; abundant, medium, scarce.

487. Study of Cotton in the Laboratory.—Give each student 5 open bolls of cotton from each of three regions of the plant—base, middle, and top, and from three types; as, sea island, long staple upland, and short staple upland; or three varieties; as, Peterkin, King, and Truitt. These should be picked and allowed to dry a couple of weeks before using. The data obtained will permit a comparison between cotton from different parts of the same plant, and that from different types or varieties.



Fiber testing machine[1]

(a) Length of lint: average of 5 determinations .... In determining length of lint, take a small sample from the middle portion of the seed. As far as possible, the middle seed of each lock should be taken. Note uniformity of length of lint over all portions of the seed.

(b) Percentage of lint: average of 5 determinations.......... Gin by hand one lock from each boll, and weigh separately total seed cotton and ginned seeds; the difference will be the amount of lint.

(c) Determine number of seeds in each lock, and note amount of fuzz and color. From above data calculate:

1. Number of bolls required to make 1 lb. seed cotton;
2. Number of bolls required to make 1 lb. lint cotton;
3. Number of seeds to the pound.

[1] This machine was used by the U. S. Department of Agriculture. Other fiber-testing machines are made by A. S. McKenzie, corner 11th St. and Ridge Ave., Philadelphia, Pa.

(d) Length of 10 seeds..........in.
Width of 10 seeds..........in.
(e) Test tensile strength..........milligrams.

N. B.—The distance between the point of attachment of fiber and the point of suspension of weight should be the same in every case.

488. Crossing Cotton.—Select plants of the type which it is desired to cross, which have a half dozen buds about to open, and remove all other buds or flowers. The flowers on the plants to be used as female parent should be emasculated by carefully clipping away the petals and the enclosed stamens, care being taken that none of the anthers are broken, and the pollen dropped upon the stigma. Both the plants of the female and the male parents may be covered with paper bags or as directed for wheat. (C. A. 196) When the clefts of the stigma open, which is usually at or just before sunrise, dust them with pollen from a flower which has just opened and taken from the plant to be used as the male parent. For convenience in handling, the petals may be clipped off of the male flower.

489. Collateral Reading.—F. Wilkinson: The Story of the Cotton Plant. New York: D. Appleton & Co., 1899.

D. A. Tompkins: Cotton and Cotton Oil. Charlotte, N C.: The Author, 1901.

C. P. Brooks: Cotton, pp. 274-308. New York: Spon & Chamberlain, 1889.

Louis Edgar Andés: Vegetable Fats and Oils, pp. 110-117. London: Scott, Greenwood & Co., 1897.

Leebert Lloyd Lamborn: Cottonseed Products, pp. 16-30, 31-40. New York: D. Van Nostrand Co., 1904.

XXIII

FIBER CROPS

I. FLAX

490. Relationships.—The genus *Linum* has been divided into many species, but in many cases the distinctions are of minor importance. The only species of commercial importance is the common flax (*Linum usitatissimum* L.). There are both spring and winter varieties, the former only being cultivated in America. There is a form of summer flax, sparingly cultivated in Europe, in which the capsules or seed bolls burst open and scatter the seed. Perennial flax (*L. perenne* L.) has been cultivated experimentally, but is of no commercial importance. Rocky Mountain flax (*L. lewisii* Pursh.), occurring widely throughout sub-arid western North America, has been used by the Indians for making cord, fish-nets, basket frames, and similar purposes.

491. Description.—Flax is an annual with a single, upright branching stem varying under cultivation from one and a half to three or more feet in height. It has a thread-like tap root, sparingly supplied with tender branches. The leaves are simple, narrow, entire, and nearly sessile. It has perfect, symmetrical, rather conspicuous blue flowers, all parts being in fives. The carpels, however, are divided by a false partition, hence the capsule or seed boll is usually ten-celled and ten-seeded. The seed boll is one-fourth inch or more in length, and the seeds vary in length from one-seventh to one-fifth inch.

492. Flax Seed.—The seeds are lenticular, compressed, with a smooth, polished surface, one-sixth to one-fourth inch long, varying in color from yellow to dark brown, light brown being the standard color. The Minnesota Station found no appreciable difference between light brown and dark brown flax seeds either in general chemical composition, properties of the oil, or germinating power.[1] The average germination of flax seeds is about 85 per cent. The Canada Station found the decrease in viability during five years to be as follows: 81, 82, 75, 49, and 26 per cent.

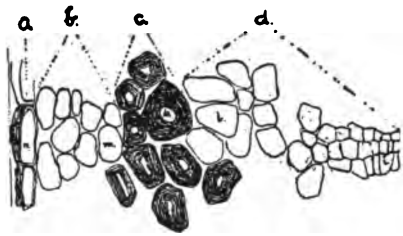
The cells of the epidermis or seed coat are filled with a mucilaginous material readily viscid in hot water, which gives flax seed its value in medicine. Flax seed has a large, straight, oily embryo consisting of two long, thick cotyledons and a short radicle. The endosperm which surrounds the embryo is comparatively thin, and in mature seeds contains no starch. The seed is characterized by its high percentage of protein and oil, 20 to 25 per cent. of the former, and from 30 to 39 per cent. of the latter. The average composition of the flax seed and of old and new process linseed meal is as follows:

Analysis	Flax seed	Old process linseed meal	New process linseed meal
Water	9.1	9.2	10.1
Ash	4.3	5.7	5.8
Protein (N x 6.25)	22.6	32.9	33.2
Crude fiber	7.1	8.9	9.5
Nitrogen-free extract	23.2	35.4	38.4
Fat	33.7	7.9	3.0

Flax is grown in America almost exclusively for its seed, from which is obtained an oil highly prized for paint and varnish on account of its quality of drying quickly. The oil is obtained by crushing the seed and heating it to 165° F., after which it is either (1) placed between cloths or in sacks and

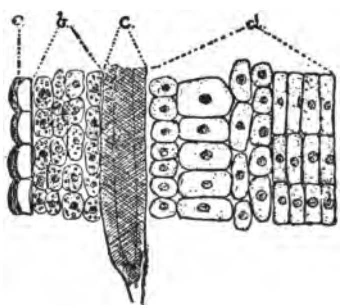
[1] Minnesota Sta. Bul. No. 90 (1905), p. 226.

subjected to hydraulic pressure; or (2) the warm meal is placed in large cylinders and treated with naphtha which extracts the oil, known in commerce as linseed oil. The resulting linseed meal is, in the first instance, known as old process linseed meal, and in the second as new process linseed meal. In either case on account of its high protein content, and because of other valuable properties, it is highly prized for stock feeding, especially for use in rather small quantities, two pounds or less per 1,000 pounds of live weight.



Cross-section of bark of flax plant: *a* epidermis, *b* parenchyma, *c* bast, *d* cambium. Enlarged 260 times (After Lugger)

The yield of oil varies in different years, according to conditions under which the the seed is ripened. Ordinarily 100 pounds of pure, clean seed produce from 33 to 36 pounds of commercial oil weighing 7.5 pounds per gallon. The oil is used extensively in the manufacture of paint, oil varnishes, printing ink, floor cloth, artificial india-rubber, and soft soap. In the manufacture of colors and varnishes it is sometimes mixed with hemp seed oil.



Longitudinal section of bark of flax plant: *a* epidermis, *b* parenchyma, *c* bast, *d* cambium. Enlarged 260 times (After Lugger)

493. Flax Fiber.—In a flax stem three zones may be recognized—namely, the pith, the wood, and the bark. The bark is further divided into four layers, the skin or epidermis, the parenchyma, the bast or flax fiber cells, and the cambium layer.

Since the tough bast cells lie between the tender thin-walled cells of the parenchyma and cambium, it is possible, by "retting" the stems, to clear the flax fibers from the adjacent cells. The retting, which may be done by allowing the stems to be exposed to dew or rain, or by placing in pools of water, causes the parenchyma and cambium cells to decay or become tender, and thus permits the tougher fiber cells to be separated. (496) The bast or flax fiber cells are from 0.08 to 0.16 inch long, but they are so completely cemented together that continuous fibers the length of the flax stem may be removed. The dry stems of flax contain from 20 to 27 per cent. of bast, 58 per cent. of which is pure fiber, 25 per cent. other substances soluble in water, and 17 per cent. soluble in alkalis.[1] When dew retted, the fiber is silvery gray; when water retted, yellowish white.

Two forms of commercial fiber are obtained: long, straight lint, 12 to 36 inches in length, and the short, tangled fiber which in dressing separates from the long lint, and is called tow. Coarse tow is also made by simply removing the remaining part of the stem and baling the tangled mass. The latter is used in upholstering and in making twine, bagging, and paper. Flax fiber is sparingly produced in Ontario, Canada, and a few of the northern United States. Flax fiber is produced principally in the cool, moist, low lying regions of northern Europe. Flax is the highest form of bast fiber, being used principally for the manufacture of laces, fine linens, dress goods, and thread.

494. Adaptation.—Flax may be grown for seed in any climate or soil in which wheat can be successfully grown. Sandy loams are rather better than heavy clay loams. For the production of the best grades of fiber, a cool and continuously moist climate and soil are requisite. It is rather easily injured by late spring frosts. It requires about 90 days to mature.

In the United States flax has always been a pioneer crop. It is customary for the pioneer to break the prairie sod about two

[1] Minnesota Sta. Bul. No. 13 (1890), p. 37.

inches deep, turning it over flat. After it has rotted one season it is cross-plowed about four inches deep, thus covering the rotted sod with about two inches of fresh soil. This is known as "back setting." On soil thus prepared wheat is usually sown.

It has been the custom in the states farther south to plant maize upon the freshly turned sod, producing a crop with little or no cultivation, while in Minnesota, the Dakotas and western Canada it has been the custom to sow flax; thus a crop is secured while waiting for the sod to rot. Flax seed is therefore a sort of by-product in the development of a new country, and this source of supply has been sufficient to meet the market demands. Further, soils soon become "flax sick" on account of the wilt disease, which causes the abandonment of flax culture in older regions.

495. Diseases.—Flax is attacked by several fungous diseases. Soil on which such attacks have occurred is known as flax sick soil. These diseases are the most serious hindrance to the successful cultivation of flax, either for seed or for fiber, but in no way do they affect the growth of other field crops. The most common one is the flax wilt disease (*Fusarium lini* Bolley), so called because the plants, attacked at all ages, die as if for want of water. This fungus starts from the infested soil or seed, and develops spores on the surface of the stems, and also within the stems and the seed. The remedy consists in a rotation of crops, in which flax occurs only once in eight years, and the sowing of pure, well-matured, clean seed. The North Dakota Station,[1] which discovered this disease, states that all samples of seeds examined contain spores. Internal spores of diseased stems and seeds cannot be killed by treatment. Hence all bits of stems and diseased seeds must be removed, after which the pure, undiseased seeds may be treated with formalin, as for seed wheat and oats. (C. A. 149) The itinerant threshing machine tends to spread the infection. Manure from animals fed on flax straw must not be used where flax is to be grown.

Another species of the genus *Fusarium*, a species of *Colletotrichum* and of *Alternaria*, are destructive to flax. Flax rust (*Melanospora lini* (D. C.) Tul.), recognized by the yellow or orange spots on the older parts of the nearly mature stems, is not considered seriously injurious to flax grown for seed.

496. Cultural Methods.—The culture of flax for seed is similar to that of spring wheat. For the best results on old land rather deeper and more thorough preparation of the soil is

[1] North Dakota Sta. Bul. No. 50 (1901); No. 55 (1903).

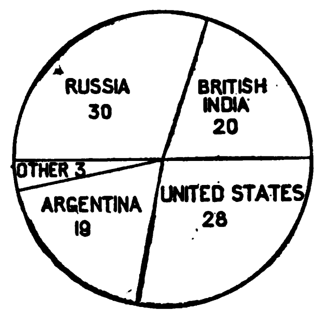
desirable. The seed should be sown from one-half to one inch deep. For the production of fiber, broadcast seeding may be practised. Great care in obtaining uniform distribution is desirable. When sown in drills the outer plants of the drill row are coarser and more branched than the inner ones, and thus materially reduce the uniformity of the product. Seeding should follow rather than precede spring wheat and oats.

Unlike the cereals, the plant is much modified by the thickness of seeding. When the stand is thin the stems produce many branches, and consequently many seeds. When sown sufficiently thick, branches develop only at the top, and few seeds are produced, but the fiber is of superior quality. When seed is the sole object, two or three pecks are used; when both seed and fiber are desired, twice the amount of seed is employed, and when fiber only is produced, three to four times the amount is used. Because of the wilt disease, special care in the selection and treatment of the seed should be observed. (495)

Flax is an easy crop to harvest with the self-binder, is pleasant to handle, and is not readily damaged while standing in the shock. It may be threshed with an ordinary threshing machine. In Ontario the crop, when grown for fiber, is pulled by hand, the work being done by men, women, and children. A man may pull one-third of an acre a day. The crop is tied in small bundles, placed in shock, and when dry sold, without removing the seed, to the scutching mills. Under favorable conditions two to three tons per acre are produced.

"The best flax is pulled, for the following reasons: (1) to secure straw of full length; (2) to avoid stain and injury, which would occur from soil moisture soaking into the cut stems while curing in the shock; (3) to secure better curing of the straw and ripening of the seed; and (4) to avoid the blunt cut ends of the fiber. Flax that has not grown well enough to produce first-grade fiber is sometimes cut with a self-rake reaper. After curing in the shock for two or three weeks the seed is threshed out, usually by holding an unbound bundle in the hands, and passing the heads two or three times between rapidly revolving rollers which crush the seed pods, the seed afterwards being cleaned in a fanning mill. The straw is then bound into bundles and stored until time for retting, in October or early November. Nearly all of the fiber flax grown in the United States and Canada is retted by spreading the straw carefully and evenly on the ground, where it is exposed to the weather for two to four weeks. After retting, it is raked up, tied in bundles, and taken to the mills, where it is broken, scutched, and hackled. In each of these operations it is picked up and handled in small handfuls, and some of the processes, especially hackling, require a high degree of skill. Numerous machines have been invented to pull flax, spread it for retting, break it, and scutch the fiber, but none of them has given sufficient satisfaction to be generally adopted. Until machines are devised to take the place of hand labor, and reduce the cost of the preparation of flax fiber, there is little probability that the industry in this country can be increased in competition with other crops which may be cultivated with greater profit." [1]

497. Production.—While one of the most important fiber crops of the world, flax is grown in America chiefly for its seed, the large production of which in the United States and Argentina has made this one of the principal oil-producing plants. The principal flax seed producing states are North Dakota, Minnesota and South Dakota. While in the United States flax is a secondary crop, in Argentina it is one of increasing importance. In the year 1902-3 the acreage of flax in Argentina was nearly equal to that of maize, and about one-sixth the total acreage of farm crops in the same country. In the same year the acreage in the United States was 3,233,229, and in Argentina, 3,221,400 acres.



World's average production, 9 years, 78,824,400 bushels
Diagram showing the percentage of the world's production of flax-seed by countries for an average of 9 years, 1896-1904

"Flax, that devourer of the richness of the land, is a crop which, necessarily, must be of a nomadic character; it cannot become a staple crop in farms worked in a regular manner, because it would absorb all the strength of the soil, and quickly produce sterility. In such cases it can only be grown at intervals of five years, after a methodical rotation of crops calculated to

[1] U. S. Dept. Agr. Yearbook 1903, pp. 391, 392.

restore to the soil the elements withdrawn from it by the flax. For the present the enormous area of virgin soil offers ample space for the cultivation of flax. But the area of land still to be broken up will soon only be found in a more distant region. So that the cultivation of this crop will become, pecuniarily, more difficult; however, it is, for the time being, a matter of large figures, rapidly increasing, in the bulk of our crops, and in the profit which its exportation returns in good gold to our farmers."[1]

The average yield of flax seed in the United States for ten years, ending 1905 was, in round numbers, 22 million bushels, and the average farm price on December 1 for the four years ended 1905 was 93 cents per bushel. Weight per bushel, soundness and uniformity of seeds are the principal factors in establishing the grade. No. 1 northern grade must weigh 51 pounds or more per bushel, and not contain more than one-eighth "field, stock, storage or other damaged seeds." The usual legal weight per bushel in Canada and the United States is 56 pounds. Of flax fiber in the world's commerce, Europe is the sole producer. Russia produces more than three-fourths of the crop, while of the remaining ten countries producing the fiber, Austria-Hungary is the chief.[2]

498. History.—The history of flax is contemporaneous with that of wheat. The clothing of the ancient Egyptians and Hebrews was largely made of flax, and its culture was introduced into Europe in remote times. Flax fiber is comparatively much less important since the general introduction of cotton. It has been called the "fiber of luxury," while cotton has been referred to as the "fiber of the masses." Its use as a source of oil has increased rapidly within recent times.

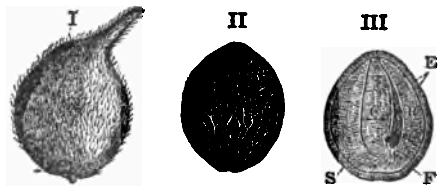
II. HEMP

499. Hemp.—(*Cannabis sativa* L.), a plant closely related to the hop and ramie, and belonging to the mulberry family (*Moraceae*), is a native of western and central Asia, having been

[1] M. Bernardez: The Argentine Estancia, pp. 94, 95.

[2] For flax culture in Europe, see U. S. Dept. Agr., Farmers' Bul. No. 274; also published as Bul. No. 71 by North Dakota Station.

cultivated in China from remote times. It is a rough, erect annual 8 to 10, in some cases 12 to 15, feet in height, with staminate and pistillate flowers on separate plants. The pistillate plants are more branched than the staminate ones, and are less valuable for fiber. The seeds on the market consist, for the most part, of naked fruits or achenes, with an occasional fruit enclosed within the hooded calyx. The seeds are oval, about one-eighth to one-sixth inch long and one-twelfth inch wide. The crushed seed emits a characteristic odor. The seed contains 30 to 35 per cent. of oil, and the yield of oil varies according to process from 25 to 32 per cent. Like olive oil, it is used for culinary purposes, and also for burning, soapmaking, and as an ingredient of oil colors and varnish. The usual legal weight per bushel of seed is 44 pounds.



Hemp seed. I Calyx; II outer surface of fruit; III longitudinal section of fruit. *F* pericarp; *S* testa; *E* endosperm; *C* cotyledon; *R* radical. Three times natural size.

(After Winton)

The "seeds" on the market consist for the most part of naked fruit with an occasional fruit enclosed within the hooded calyx.

Hemp thrives best in a temperate climate, and may be grown on any soil adapted to maize. Where the waste products are returned to the land, it is not considered an exhaustive crop. In some places it is grown continuously for many years on the same land. This, however, is not a desirable practise, if for no other reason than on account of the possible attacks from broom-rape (*Orobanche ramosa* L.), a parasitic plant which is sometimes quite destructive to hemp, and for which a rotation of crops is the best known preventive. In America, hemp is raised chiefly in the blue grass region of Kentucky and Tennessee, although it has been grown successfully in more northern states. It is usually sown broadcast at the rate of four to six pecks per acre between oat sowing and maize planting. It fully subdues all weeds.

Hemp is considered ready to harvest when the first ripe seed is found in the head, which requires about 100 days. The harvesting depends somewhat upon the rankness of growth. Hemp is cut with a mower or self-rake reaper when not too large, or by hand, as in the case of maize. It is allowed to lie on the ground until retted or rotted by dews and rains, when it is shocked or tied in bundles and stacked. In some cases the hemp is broken in the field, thus leaving the waste products upon the soil; in other cases it is carried to a central place where more rapid machinery is used. The yield of fiber may be from 500 to 1,500 pounds, and of seed from 10 to 30 bushels per acre. When grown for seed, hemp is planted like maize, at the rate of two quarts per acre. When retted by dews and rains, as is the custom in this country, the fiber is gray and somewhat harsh, but when retted in water, as in Italy, the fiber is creamy white, lustrous, soft and pliable.

Hemp is raised in this country for its fiber, but it is widely raised elsewhere also for its oily seed and for the resinous exudation from its leaves and stems, from which intoxicating preparations are made. The hemp fiber raised in this country is used chiefly for cordage and warp for carpets.

III. JUTE

500. Jute fiber is obtained from two closely related annual plants (*Chorchorus capsularis* L. and *C. olitorius* L.), belonging to the linden family and native of Asia. In general, they resemble hemp. The first form grows nine to ten feet high, and has short, globular seed pods, while the second, nalta jute, is smaller and has elongated, cylindrical pods. The bast fibers of both are practically the same. The leaves of the nalta jute are also used as a vegetable.

Jute may be successfully grown in the cotton belt. These plants prefer a moist, warm climate, and rich, alluvial soils. Seed may be sown broadcast about the same time as cotton, using 15 to 20 pounds of seed per acre, or may be started in beds and subsequently transplanted. Plants are harvested by cutting close to the ground or pulling up by the roots. Jute will not become an established industry in America until some means of economically extracting the fiber from the stalk has been devised.

Jute is principally cultivated in Bengal, India, and is largely exported to this country, being the cheapest fiber used in American textile manufacture, and used more largely than any other, except cotton and sisal. It is usually employed for cotton bale covering, bagging, twine, and carpets. When exposed to moisture, fabrics made from jute soon lose their strength because the material which cements the cells together is dissolved. The fiber in the lower 5 to 25 inches of the stalk being coarse, is cut off and sold at an inferior price under the name of jute butts, while the remainder of the fiber—finer, softer, and more easily spun—is sold as jute fiber.

IV. RAMIE

501. Ramie (*Boehmeria nivea* Gaud.) is a perennial shrub with herbaceous shoots, belonging to the nettle family. It somewhat resembles hemp in general growth and appearance. It is an inter-tropical plant, and grows readily in the Gulf states where a good supply of moisture, coupled with thorough drainage, is obtainable. It has been grown in this country in an experimental way only.

The plant may be propagated by seeds, cuttings, or division of roots. If by seeds, the plants are started in hotbeds. Cuttings of the ripened wood, including three buds, are set like willow cuttings, with the middle bud at the surface of the ground. Propagation by division of the roots of the fully matured plants is recommended for this country. The plants should be placed about as thickly as the hills of maize.

It has been grown in eastern Asia from remote times in a limited way. The fiber is there extracted by hand by a slow and tedious process, and is used for cordage and other coarse manufactures as well as for making textiles of great fineness and beauty. It can never become an important industry until some machine is brought into use which will economically extract the fiber from its green, tough, and gummy bark.

V. MANILA FIBER

502. **Manila Fiber** or Abacá (*Musa textilis* Neé), usually called manila hemp, is a hard or structural fiber coming from one or more perennial species belonging to the same genus as the common banana, and which occur only in restricted areas in the Philippines. The plant requires abundant rainfall, a moist atmosphere and a well-drained soil.

The plants are propagated from suckers or seeds, chiefly the former, set in hills five to eight feet apart. They require no cultivation, since the rapid growth soon shades the ground. Small shrubs which sometimes occur are cut out with bolos. Plantations thus started may last for generations. The plant is harvested as soon as the flower bud appears,—about three years from planting when propagated by cuttings, and about five years when seeds are sown. The plant attains a height of 8 to 20 feet, and the leaf sheaves of which the stems are chiefly composed are 5 to 12 feet in length. As soon as cut, the leaves are divided into thin strips and drawn by hand under a knife held by a spring against a piece of wood, which scrapes away the pulp. One laborer may harvest about 25 pounds of fiber a day. A fair yield of fiber is estimated at from 350 to 500 pounds per acre annually. The average yield of the cultivated area in the Philippines, in 1902, was approximately 275 pounds per acre. The production of manila fiber is the most important industry of the Philippines, and constitutes more than half the value of the exports.

Manila fiber. Native Tagalog woman, about five feet tall
(From photo by Gilmore)

"The best grade of manila fiber is of a light buff color, lustrous and very strong, in fine, even strands 6 to 12 feet in length. Poorer grades are coarser and duller in color, some of them yellow or even dark brown, and lacking in strength. The better grades are regarded as the only satisfactory material known in commerce for making hawsers, ships' cables, and other marine cordage which may be exposed to salt water, or for well-drilling cables, hoisting ropes, and transmission ropes to be used where great strength and flexibility are required. The best grade of binder twine is made from manila fiber.

since owing to its greater strength it can be made up at 650 feet to the pound as compared with sisal at 500 feet." [1]

VI. SISAL

503. Sisal.—Several species of the genus *Agave*, to which the century plant belongs, have been cultivated in Central

Carrying hemp. Manila
(From photo by Gilmore)

America for many hundred years, the most highly prized and the source of commercial fiber being the sisal plant (*Agave rigida* Miller), known in Spanish speaking countries as henequin.

The fiber is a structural or hard fiber, and is obtained from

[1] U. S. Dept. Agr. Yearbook 1903, p. 395.

the large, thick leaves by crushing with machinery, the most improved types of which will crush 150,000 leaves daily. A thousand leaves are estimated to produce 50 pounds of fiber. Under favorable conditions a yield of 600 to 1,200 pounds of fiber per acre may be obtained. The fiber is yellowish white, two and a half to four feet in length, harsh and lacking in flexibility and easily decomposed by salt water. Next to cotton, it is the most extensively used fiber in the United States, being used principally for binder twine and for mixing with manila fiber in the manufacture of cordage of various sizes. Door mats and other coarse floor matting are made largely of sisal. Yucatan sisal is shipped in bales weighing from 350 to 400 pounds.

The sisal is a tropical plant growing on barren, rocky land, useless for other agricultural purposes. It develops best in a limestone soil and a comparatively dry climate. Its cultivation is confined almost exclusively to Yucatan, the West Indian Islands, and Hawaii, the former being by far the chief source of the commercial fiber.

"The sisal plant is propagated by suckers springing from the roots of old plants, or from bulbils. Bulbils, called 'mast plants,' are produced in great numbers on the flower stalks in place of seed pods, like onion sets. The plants are set out during the rainy season, in rows four to eight feet apart, in holes dug in partly disintegrated coral or lime rock with crowbars, pickaxes, and sometimes with the aid of dynamite. The ground where sisal is grown is usually too rocky to permit any stirring of the soil. About the only care given is to cut the brush and weeds once or twice each year. The weeds and brush, largely leguminous plants, by decaying on the ground add fertility to the soil. The first crop of outer leaves of the plants is cut at the end of three years when grown from suckers, or four years when grown from mast plants. From ten to twenty leaves are produced each year for a period of twelve to twenty-five years in Yucatan, ten to fifteen years in Cuba, and six to twelve years in the Bahamas. An unusually cold winter at any period tends to check growth and cause the plants to send up flower stalks, after which they die." [1]

VII. MAGUEY

504. THE MAGUEY PLANT (*Agave cantula* Roxb., *A. vivipara* L.) has the same habits of growth, and is propagated by the same methods as the sisal

[1] U. S. Dept. Agr. Yearbook 1903, pp. 395, 396.

plant, to which it is closely related. Like the sisal plant, it is adapted to a tropical dry climate and a thin, rocky limestone soil.

"The henequin of Yucatan, *Agave rigida elongata* Baker, the sisal of Hawaii, *Agave rigida sisalana* Engelmann; and the maguey of the Philippine Islands, recently identified at the Royal Botanic Gardens, Kew, as *Agave cantula,* are very similar plants. All have the short, thick stem; the aloe-like cluster of large, fleshy leaves; and the tall flower stalk, or 'pole,' which bears a large number of small bulbils, or pole plants. The Hawaiian plant differs from that of Yucatan in having a shorter trunk; leaves smooth-edged, or bearing a few unequal teeth; and the fiber less in quantity, but superior in quality. The Philippine maguey plant has a short trunk; leaves from 4 to 6 feet long, from 2¾ inches wide at the base to 4 inches wide at the middle, and about 1 inch thick at the base; lateral teeth three-fourths to 1¼ inches apart; dark-brown terminal spine one-half inch long; and fiber fine, white, and longer, but less in quantity than either the Yucatan or the Hawaiian varieties." [1]

While native of Mexico, it is now grown in a minor way in nearly every province of the Philippine islands. The production of maguey fiber, known in England as manila aloe, is small compared with manila fiber in the Philippines, or sisal in Yucatan. The production is increasing, however, and it is believed that by the introduction of sisal breaking machinery to take the place of salt water retting and hand cleaning, the production may be greatly increased, and the quality somewhat improved. It is generally used for the same purposes as sisal, and sells for slightly less per pound.

VIII. ISTLE

505. Istle or Tampico fiber is produced by four or five different species of plants closely related to sisal growing wild on the arid table lands of northern Mexico, and southern Texas, and New Mexico. There are three types of this fiber recognized—namely, (1) Jaumave istle (*Agave lophantha* Schiede), 20 to 40 inches long, almost white, and nearly as flexible as sisal; (2) Tula istle (principally from *Lamnella carnerosana*), twelve to thirty inches long, coarser, and less flexible; and (3) Palma istle (*Agave lecheguilla* Torr.), 15 to 30 inches long, coarse, stiff, yellow in color and somewhat gummy. Originally used only for the manufacture of brushes, it has lately been employed for mixing with other fibers in the manufacture of the cheaper grades of twine and larger cordage.

IX. NEW ZEALAND HEMP

506. New Zealand Hemp (*Phormium tenax* L.), sometimes called New Zealand flax, produces a hard or structural fiber. It has been tried experimentally at the California Station, and is sometimes grown on the Pacific coast as an ornamental plant, but has never been grown commercially in America. The commercial supply of fiber comes exclusively from New Zealand.

[1] Dept. Interior, Bureau Agriculture, Farmers' Bul. No 13 (1906), pp. 11, 12.

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